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PROSPECTUS

If you're like most executives, you read articles and books about business management for not one but several reasons. First, you want to "keep up" with what's going on in the economy — general trends, problems, names in the news, and so forth. Second, you're curious about the great moral, social, and political issues of our time — what they are and what they may mean for industry. Third, you find some of your reading helpful in a practical way on the job, just as a doctor or lawyer finds professional help in a medical or legal journal.

It is the third reason that we are most concerned with in *Business Briefs*. For our quarterly selection of reprints from other magazines we concentrate on materials that throw light on the *operational* aspects of management, that help one to broaden his administrative perspectives. Many publications are rich sources of articles of this kind. Take, for example, the journals represented in this issue. *Sales Management*, from which the lead article is drawn, has consistently proved helpful to marketing men. *The Journal of Industrial Engineering* (Salveson article) keeps know-how circulating among engineers and production managers. The carefully edited *Personnel* (Taylor article) has upgraded administrative practices in company after company. *Purchasing* (Ammer article) has long been a "prime mover" for improvement in the procurement field. And *Trend*, from which is drawn the short glossary (and the tongue-in-cheek quote from the London *Economist*), publishes valuable data for managers in Great Britain.

Have you come across articles in your reading that you consider especially helpful or provocative and that you would like to share with 2,500 other HBS alumni? If so, drop us a card with the title and reference — or tell Don Wright the next time you see him at an alumni club meeting. If your article seems to fit in, we'll include it in a future issue.

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DAVID W. EWING, *Editor*

P.S. The "strap-hanger" on page 36 was drawn by Mark Kelley, Jr.

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Would you like to know the results of a marketing decision before *you make it? Would you like to find out how several different plans might turn out? Hang on. The scientific techniques that hold the answers are coming fast. In fact, some of them are already here.*

WHAT'S THE STATUS OF MATHEMATICAL MARKETING?

By Kenneth M. Reiss

It's 1965, or perhaps a little beyond. The scene is a special meeting of the marketing committee of the Bevatron Popcorn Co. The reason for the meeting: Bevatron, although in firm possession of 40% of the bagged popcorn market in the area, has just posted its third successive red-ink quarter. Worse, market intelligence shows that Bevatron's two competitors, Ajax and Atlas, are raking in profit hand over fist. Why? They charge more — one gives 11 ounces for 12 cents, the other, 15 ounces for 15 cents — and consequently receive a smaller share of the market. Bevatron's trouble is now clear; all efforts at cost reduction have failed, so the famous Bevatron 10-oz. bag for a dime must go.

Several alternatives are selected as holding the greatest promise: (1) raise the price a penny; (2) reduce the size of the bag to 9 ounces; (3) raise price 2 cents, up the bag size only 1 ounce; (4) "trade up" each sale by increasing both price and size of bag by 50%.

But plenty of disadvantages are evident, too, not the least being that it is impossible to say which plan would maximize

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profits while minimizing the damage to sales and industry position. Plan 1 is obviously the most flagrant price rise; it would undoubtedly irritate customers, and would certainly spell doom for the company's well-promoted advertising slant of "still only a dime." It would involve considerable public crow-eating, to be sure. But plan 2 would create the smallest bag of popcorn in industry history — one that might be too small for consumer tastes. And it just temporarily avoids the price-rise issue. Plans 3 and 4 mean matching competitors exactly. Both are active, responsive companies — and would be sure to retaliate. Even a price war is not out of the question. And these plans, while probably the soundest fiscally, would probably do most damage to Bevatron's industry position.

Today, there would be no way to get answers to the questions raised by our little fictional problem. But Bevatron, with 1960 a good five years behind, can use computerized mathematical analysis, or, as the company calls it, the "Predictron" system. By using these advanced techniques, it can get answers to the questions, "What would happen if we did 1? . . . 2? . . . 3? . . . 4" In each case, what would happen to sales? To industry position? What would competition do? With answers to those and other questions, the committee could meet again . . . decide which probable outcome best fits the company's long-range goals . . . and implement that plan quickly and confidently.

FABULOUS TOOLS

Right now, unfortunately, mathematical analysis is not so sophisticated. It is, in fact, largely a laboratory phenomenon — still quite untamed.

The brother-sister act of applied mathematics and the electronic computer is enough to scare the pants off of any sales or marketing executive. The long rows of hieroglyphic formulas . . . the strange, apparently untranslatable jargon of the trade . . . the intricate language understood only by machines and a select few mortals . . . indeed enough to put fear of the devil in the sales-trained marketer.

But woe to him who avoids that ice-cold duet of formula and machine. As 1965 heaves into view, it will be a major factor in marketing decision making. Indeed, some think it will be the most significant development yet in modern marketing. But it can't be brought into a company overnight.

It must be made very clear that no formula or machine will be making marketing decisions. Rather, the "decision systems" are tools — fabulous tools which allow the marketer to base his major decisions on reliable information, rather than on hunches and incomplete knowledge. In effect, it puts him in a class with the engineer whose theories assure him that his bridge will stand before the first girder falls into place.

To obtain a more exact picture of the role played by this new technology, it may be helpful to see how it fits into the over-all decision-making process.

This is how one expert describes it:

> "It is useful to break the decision process into four distinct steps. First, we have *dissatisfaction* with existing operations, which leads to *nomination* of some alternative course of action. This is followed by *prediction* of what the effects of the alternative will be. This leads to *evaluation* of the predicted effects to determine whether or not the plan is satisfactory — if not, the process reverts to the first stage; if so, we take action. Our general hypothesis is that humans are far superior to computers in three of these components: dissatisfaction — sensing that something is wrong and that a change should be made; nomination — coming up with a totally new plan; and evaluation — comparing the expected outcomes of several different plans and deciding that one is best. We believe that in the prediction stage, however, computers and mathematical analysis may be far more effective than human intuition. The determination of the possible effects of a change in some aspect of a plan requires precisely the kind of detailed, exhaustive analysis in which computers and mathematics excel."

This is how it works: The computer simply predicts by quickly solving extremely long mathematical problems fed into it by operations researchers (operations research, applied mathematics, mathematical programming are, broadly, all names for the same activity). It is still up to the sharp marketing executive to wonder, "What would happen if we did 'A'? or 'B'? or 'C'?" And, when he finds out what would happen if he did any of the three, it is up to him to decide which path best leads to the fulfillment of his company's goals (also established by a person — not a machine), whether they be higher profits, more sales, more diversified line, de-emphasis of certain products, larger share of industry for others, and so on. The decision system of applied mathematics and computer has told him one thing: What would probably happen if he followed each of his proposed courses of action.

Incidentally, it is the ultimate wish of the operations researcher to eliminate himself as much as possible from the procedure. So long as he is between the executive and the machine, the process is limited to

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simple problems. By the time a complex problem is translated from executive language to operations researcher language to computer language and back again, the meaning and content is virtually destroyed. The problem is to enable the executive to communicate with the computer with as little interference as possible. The thought is not to make operations researchers out of marketing executives — but to make the computers more and more articulate and receptive. The ideal, of course, would be to have the executive address the machine simply, have the machine understand, translate and set up its own problem, solve it, translate its answer back to the executive in language he could understand easily.

Today, the average marketer has no definitive scientific predictions to help him. So he must make his own predictions. After he decides what might be done as an alternative to the present method, he begins to gather information. He succeeds in assembling vast amounts of data. But voluminous as it is, it is probably somewhat incomplete. He most certainly has only a superficial knowledge of the relative importance of each scrap of data, and has no way of knowing for sure exactly how each facet is interdependent with others. He often has no way of knowing what information will be obsolete by the time his alternative suggestion would be in use. He has only a sketchy idea of what new information is needed for an evaluation of a new procedure, or of how to obtain that information. In short, he has the super-human task of completing and exactly weighing mountains of information that is figuratively crawling with unknowns, obscure causes and effects and conflicts.

And he must go through this for each alternative that is to be studied. There is not a man alive who has the time or ability to fully and accurately make such a desirable set of exact predictions.

Fortunately, such major decisions are relatively rare in marketing. At least, decisions involving a free choice among several alternatives are rare. Major policy decisions are kept to a minimum by the expense of changeover and the loss of effectiveness that is often felt during the transition period. Then, too, many decisions, both in major strategy and minor policies, are not the results of free choice. They are, in fact, often dictated by internal policies or the competitive situation.

PROGRESS REPORT

It is, of course, obvious that the mathematician's job of reducing the mountains of information needed for an accurate prediction into mathematical language that correctly assigns the right weight and the proper relationship to each tiny bit of data is almost impossible. And there are many tough nuts that remain to be cracked. But much progress has been made already, and work towards a more complete solution is advancing rapidly. This is about where it stands now:

Basically, it is now possible to use a mathematical prediction system on internal problems, especially those of a logistical nature. In addition, it is also possible to obtain incomplete but helpful predictions of the outcome of suggested external activities.

For example, the revision of a distribution network might make good fodder for the machines. Say, for instance, that over the years a shift in population has made a particular system of centrally located district distribution centers obsolete and costly. The biggest facilities are operated below capacity; others are overtaxed. Many are located too far from areas that have become the most important markets. A number of revisions might be suggested, analyzed mathematically, and the results studied to determine what moves would best accomplish the desired ends. This is a relatively simple procedure (compared to many now under study). At today's levels, it would still be incomplete as far as human factors would be concerned; such problems as the morale of workers, customer reaction, relocation of salesmen, etc., are still not subject to everyday quantitative analysis.

The more external in nature the problem becomes, the more incomplete is the prediction. A pricing problem might offer an example. Assume that a particular item that sells to distributors for $10 is selling badly this year. Its maker, Fritewigs, Inc., feels certain that next year will be a banner year. The problem is to get some of next year's business now. This can be done by lowering price on items purchased this fall (and paid for early next year). How far should the price be lowered to create a maximum incentive for the supplier to overstock during the special sale? How many items should be sold to give maximum benefit to the company this year and minimum damage next year? At what price can the company afford to sell what volume?

Again, mathematical analysis can predict what would happen at various prices. But at this time, some of the prediction would have to be filled in by the marketer. For example, a bold move by a competitor could really throw a monkey wrench into the works. The market for the product could suddenly drop, making next year a disaster. Right now, the inclusion of such outside influences in most cases creates a problem that is a little too sophisticated for mathematical prediction.

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But it must be remembered that although a complete analysis is sometimes impossible in external problems, the portions that are workable are far superior to traditional by-guess-and-by-gosh methods. In other words, many problems of a more limited nature can be worked on quite satisfactorily by today's mathematical methods; for broader problems, applied mathematics can at least be of help.

TOP DRAWER

For the researcher, the emphasis is very definitely on developing satisfactory techniques for predicting the outcome of problems that involve a competitive situation. It's not a pie-in-the-sky problem, either. For the most part, the mathematical techniques are known. Many of the cause-and-effect relationships needed for the equations are known; others need further research but experts are confident that answers exist, and time and study are all that are needed (an example of such a relationship: the effect of advertising on sales).

Great amounts of time and study are being devoted to the problem. Many large companies, such as General Electric, Sylvania, Du Pont have sizable research departments with their own computers for just such studies. The computer makers, such as IBM and Remington Rand, are pouring research into applied mathematics in antipication of fatter markets for their machines. Independent consultants are forging ahead, stimulated by the thought of providing smaller companies with a mathematical analysis service. Colleges and universities are spurred on by private grants. And the military, which was in large part responsible for many of the basic theories, continues its research programs.

The major reason for the top-drawer classification of these widespread research programs: The stakes are phenomenally high. The results of one organization's laboratory experiments give some idea of its importance.

For some time, this organization had been running "business game" sessions. In the business game, groups of executives are divided into competing "companies." They are given a product and a certain amount of money. They plan their "company" strategies (by quarters) for marketing, production, research, etc., and their plans are run through a computer. The results are announced, and the game is continued into the next quarter. (Needless to say, these exercises, while amazingly realistic, do not involve the complexities of real life.)

Note that the computer is used only for the purpose

Other Uses of Computers in Marketing

The "model building" techniques described in the story are but one example of the many ways mathematics is used in decision theory. Others include such techniques as linear programming, theory of games, and the like.

But the same revolution in mathematics and electronics that has given rise to decision theory has spawned a wide variety of other uses for computers in marketing.

Here are just a few such uses that were gathered by Sales Management with the help of IBM and Remington Rand. Some of these applications can be performed on the very simplest punch card machines. Others may require somewhat more sophisticated equipment.

• Up-to-the-minute sales analysis in depth. Example: Easily available on punch cards is such information as population and percent of total population, plus retail sales in various categories, for every town, city and county in the U.S. (a leading source of such cards is Sales Management's Market Statistics Department, which produces the Survey of Buying Power in both book and punch card form). Any amount of other information can be punched into these cards: break-down by sales territories, share of industry expected for each product line, previous years' sales, accounts receivable, and so on. Depending on what other information is included, these cards can be used for such things as:

- — establishing sales quotas, by territory.
- — comparing sales with past performance and quotas.
- — finding sales per territory by product line.
- — spotting unusual sales drops or rises in individual territories.
- — keeping up-to-date on commissions.
- — year-end analysis to show up trends; dying markets, developing markets, needed changes in field, etc.
- — allocating advertising.
- — spotting geographical preferences in color, size, style.
- — determining ratio of co-op payments to sales in various areas.

Such reports are not only in real depth but make the information available days, instead of weeks, after it happens. Such information of course is invaluable in preparing accurate, detailed sales forecasts.

• Year-end (or more frequent) analysis of customer action — who bought what, in what amounts, which customers represent the fastest-growing accounts, etc.

• Inventory analysis that calculates what items are likely to be needed in what frequency from what warehouses, thus cutting down maintenance of excessive stocks.

• Determination of exact cost of items manufactured — so prices can be established just as low as possible.

• Setting the most realistic delivery dates for orders.

• Establishment of optimum shipping procedures between various points.

• Evaluation of day-to-day sales of a new product — including the evaluation of differing promotional methods, buying peaks, repeat sales, etc.

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of showing the results of final decisions; it is not used to help the executives predict before they choose their courses of action. In all, this particular organization ran more than two dozen such sessions. Then, recently, one of the four competing teams was allowed to use the computer for prediction before it settled on a course of action. The other three teams proceeded to make decisions in the manner usually used.

The results were amazing. The team that was allowed to use the computer to predict, not only earned higher profits than the other teams (by a factor of five to one!), but earned the highest profits of any of the hundred or so teams which had previously done the exercise.

This is indeed stimulation enough; but there is one other factor that is responsible for the high degree of interest in the development of decision-aiding techniques. That reason is the computer itself. In the early fifties, owning an electronic computer was something of a high-level fad. Through no fault of the companies making them, the machines were somehow glamorized to the point of being "wonder brains." Many companies bought them, used them for a variety of drudge tasks (payroll, bookkeeping, etc.), and were frankly disappointed. In many cases, the machines cost the company as much to keep around as the corporate president; yet they gathered dust, unplugged, most of the time.

It was not long before they were given other, more important tasks to do. Sales data could be assembled on an up-to-the-minute basis. Inventory snarls could be ironed out by the fast-moving machines. But the emphasis was still on saving, rather than making, money — and it takes a lot of saving to keep hardware like a computer on the assets side of the ledger. Now, with prediction techniques, the computers will be put to use to make money. And it can't come any too soon for most companies.

SYSTEMS SIMPLIFICATION

To get a clear idea of how far the mathematicians have progressed, and what major obstacles they are encountering, it is necessary to have a basic understanding of just how a mathematical marketing prediction is made. The technique which is probably most widely used today, and which seems to hold the most promise for future development, is "systems simulation."

Simulation is mathematical model building. It is really just a logical expansion of the process of scientific market analysis. It is comparable to the theoretical, or formula, step in an engineering problem.

Look at it this way: The best way to see how something will work is to try it. For the engineer, this would mean building the airplane just to test a new idea — just on the hunch that it would work. Obviously, this is expensive and impractical. It is comparable to the marketer who plunges headlong into a full-scale marketing program simply on the basis of his experience — also frequently a costly procedure, but one that has to be followed all too often.

The next best thing for the engineer would be to construct a scale model and test it in a wind tunnel. But models are also expensive, and to be really sure he had the best possible design he would have to create a number of different ones. Again, he would not be likely to plunge headlong into this step. But this is where the marketer gets off; the creation of a small physical model (the test market) is just about as much removed from the real thing as he has been able to get.

But the engineer has a better way to begin: He can, with the aid of mathematics, create a "model" on paper, a series of equations that literally represent the physical airplane. And different figures and dimensions can be plugged into this "model" until the best combination is found. This is precisely what the operations researcher would like to be able to do with suggested marketing programs — to see if they would be able to get off the ground.

VALUES AND RELATIONSHIPS

The big problem is immediately evident: putting marketing into mathematical form. Yet, this is not so impossible as it might seem at first glance. For example, what happens when the marketer himself studies a recommendation to see how it would work? Unconsciously, he does build a form of mental model. He tries to view the situation as a whole, in perspective as much as possible. He unconsciously assigns weights to various parts — knows that one thing is more or less important than another — to help himself judge a probable outcome. It is inexact, to be sure, but it does indicate that the assignment of numerical values to marketing problems is legitimate.

Perhaps the toughest part of the problem lies in discovering the correct relationships within the model. Virtually everything in marketing is an effect of one or more things, and is in whole, or part, the cause of something else. Every numerical value and relationship must be expressed as accurately as possible in equation form, if the model is to be a usable representation of marketing life.

This, by the way, is why operations researchers have been able to apply their prediction techniques and

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models to production and engineering problems with such success. For example, wonderful mathematical models have been built to simulate extremely elaborate oil refining systems — systems which are far too complex for the human mind to hold in their entirety. It can be done with models because all the chemical and engineering steps are known, and the interrelated processes are facts of science.

RANGE OF ACCURACY

But again, the marketing problem is not all that impossible. Indeed, tremendous progress is being made. Of course, there will always be unknown factors in marketing. The problem is to reduce the number of unknowns as much as possible, then make estimates on the rest as accurately as posible. This is what Gerald B. Tallman, associate professor, School of Industrial Management, Massachusetts Institute of Technology, says about the construction of mathematical marketing models:

"We must represent each circumstance and action which is believed to have significant influence on the nature and working of the system. Each item must be assigned some quantitative expression of its influence and of the rate at which it may be expected to change under the influence of other things with which it is interdependent. In order to develop an operable model, all expressions of relationship of incidence and rates of change must be explicit. It is obviously desirable that, in so far as possible, the data introduced into the system model be drawn from real life experience; but, with the acceptance of certain risks, it is altogether feasible to substitute hypothesized estimates where real information is lacking."

A quick look at the four basic types of equations used in making marketing models gives a good indication of how accurate the models can be. These equation types are reported by Robert S. Weinberg, manager, Market Research for IBM, in the book, "An Analytical Approach to Advertising Expenditure Strategy," which was recently released by the Association of National Advertisers. Here are the four types of equations:

1. **Definitional.** These are completely reliable, because they express exact relationships, much like the laws of nature. The simplest might be "profits equals sales minus costs." Of course, many more highly intricate relationships have been discovered. (Here is one on profits, developed by the Market Research Corporation of America: "Profits of competitors, at competitive equilibrium, are proportional to the cube of their manufacturing margins, that is, the margin between manufacturing costs and price.")

2. **Technological.** These equations deal with the interaction of technological or physical processes. An example might be shipping time or warehousing expense. These equations, too, can be completely accurate as long as the process described does not change.

3. **Behavioral.** The biggest fly in the ointment, this deals with how people will respond to a given stimulus. The people: customers, employees, competitors. This is the major reason why marketing models of competitive marketing situations are still in the laboratory stage. In the first place, such equations cannot be mathematically perfect, as human behavior is never totally predictable. It can be reasonably estimated, especially for the more stable behavior patterns, but much more work is needed along these lines.

It is the presence of competitors that really complicates things. It has been demonstrated that for a model to accurately predict the outcome of something, all the interactions must be expressed. Of course, how a competitor reacts to a company's marketing strategy is one of the most important relationships to be considered. Now, if a company has five competitors, and each could react in dozens of different ways, the complications are exhausting to think about. To include all these possibilities, the formula for the model would be yards and yards long and would take years to create.

Fortunately, a few ways out are under study. One is simply to use the best strategy that each competitor could come up with. But this, too, takes a lot of effort, and, since all competitors probably won't do the very best thing they could do, it might mean that the outcome predicted by the model would be too conservative. Another alternative is to select top executives within the company, have them act like competitors and play a regular computerized business "game" against the model. This, of course, assumes that the executives are as bright as those who work for the competition and would settle on solutions as effective as their counterparts'.

4. **The institutional equation.** Like the first two, this type of equation generally can be made to be

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quite accurate. This one involves company policy, the Government (laws, taxes, etc.) and other constraints on marketing. The equations can be accurate as long as these constraints do not change.

Incidentally, these equations point out one great value of the models besides their value as predictors: They show up, with great clarity, important gaps in information. Things that should be known to a company, but that, for some reason or other, seldom are fully known.

In any event, this is the situation: Right now, these methods of mathematical analysis are practical for internal or logistical problems, and for those phases of major competitive problems. In business the big companies are way ahead in the use of mathematical analysis. But the smaller companies are by no means left out; there are plenty of outside consultants available. Big company or small, it's still expensive. An outside consultant would program a logistical problem today for about $100,000, provided its customer is in possession of fairly complete and up-to-date information on itself. If the stakes amounted to about $1 million or more per year on a continuing basis, the job would be well worth it. The company need not even own its own computer; the model is the big thing, and once that is in hand, it can be run on a computer rented for a short while (or borrowed from a big company that is a major supplier of the company in need of it).

LOOKING AHEAD

Five years from now the use of mathematical analysis for logistical predictions will be widespread. Much more will have been done on competitive problems. Indeed, it may be that some models will be complete enough to be extremely useful. Certainly, more factual data about marketing will be known, and will be used in everyday marketing decisions made by executives.

Maybe the executive will be able to work directly with the computer, without the operations researcher, in five years. He surely will in a decade.

Mathematically derived predictions will mean big things to marketing, in particular to those companies which are the first to employ the techniques. But, as previously stated, these techniques, even when refined, cannot be brought into a company overnight. Because much of the formula is based on history, preparations in the form of accurate and complete observations must begin now.

ROLE OF MANAGERS IN DEVELOPMENT

I do not for a minute wish to disparage the importance of engineers and of technical knowledge in development. It is crucial; it is an acute shortage; it does demand, as Sir Charles (Snow) says, strenuous educational efforts in the West as well as in the developing countries to add to the body of such men available to perform in the developing countries. And yet I propose to argue that . . . management is surely no less important than the engineering and scientific know-how and, indeed, may well be more important. It seems to me that the evidence of the past shows clearly that economic growth and industrial development are the product (1) of the effective combination of of those who concentrate on technological progress and (2) of those who plan and organize and inspire human beings actually to do the things made possible by the scientists and engineers. It seems to me there is quite clearly little record, even in the Soviet Union, of material progress in which scientists and engineers have been the only initiating force.

Stanley F. Teele, "*Fundamental Issues in World-Wide Industrial Development*" Address to World Affairs Council, Albany, New York, April 21, 1960

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"Shocking as it may seem to mathematicians, quite a lot of quite intelligent people do not know the difference between a linear and a non-linear function."

— The Economist, October 31, 1959

A GLOSSARY OF STATISTICAL JARGON

ARE YOU A LATIN SQUARE?

However hard an expert may try to keep his reports free from technical terms, they slip in more frequently than he realises. Below are definitions of some statistical or mathematical terms that may well occur in everyday use. No attempt is made to give mathematical formulae or to define theorems; this is not a primer to statistics. The object is simply to translate some commonly used terms into everyday language.

Arithmetic Mean. This is the ordinary average — the sum of all the measurements divided by the number of measurements. But in statistics there are other kinds of averages — the median, mode and geometric mean.
(See example at end of article.)

Battery of Tests. A term used in applied psychology for a group of tests to which subjects are submitted. The most usual aim of such analysis is to provide predictions of each subject's aptitude for certain occupations on the basis of a weighted combination of the results of the tests.

Centiles (an abbreviated form of percentiles). Hundredths. The 90th centile is a value exceeded by only 10 per cent of the observations.

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Chain Index. An index number in which the value at any given period is related to a base in the previous period, as distinct from the ordinary index which is related to a fixed base.

Cluster Sample. When it is required to sample from a population found in groups or clusters, such as people in households, the sampling is sometimes carried out by selecting a sample of clusters, perhaps geographical areas, and observing all the members of each selected cluster. This is known as cluster sampling, or possibly area sampling if geographical subdivisions are used.

Confidence Limits. In many applications, especially in controlling the quality of an industrial product, it is useful to find two numbers between which it can be asserted at any desired level of confidence (say 95 per cent of the time), that a given population lies.

Deciles. If a series of observations is arranged in order of ascending magnitude from the smallest to the largest, the deciles are the nine values which divide the total number of observations into ten equal parts.

Frequency Distribution. This is simply an orderly arrangement of a series of data grouped according to magnitude. The choice of the groupings or classes is essentially arbitrary; but we seldom find fewer than 6 classes or more than 15. In the example at the end of this article, 8 classes or groups are used with a range of values of 5 in each class. The range of 5 is often called the class interval.

Geometric Mean. The geometric mean of two numbers is found by multiplying them together and finding the square root of the product. The geometric mean of n numbers is found by multiplying them together and finding the nth root of the product. The geometric mean is not influenced by abnormal observations to the same extent as the arithmetic mean and it is always less than the arithmetic mean.

Harmonic Mean. This kind of average is the reciprocal of the arithmetic mean of the reciprocals of the values we wish to average. This is rarely used but may be the appropriate average when dealing with rates such as speeds.

Histogram. A block diagram used to portray a frequency distribution in which rectangles proportional in area to the frequency of occurrence are erected on a horizontal axis; the width of each rectangle is proportional to the class interval of the variable.

Latin Square. A form of experimental design which has been used a good deal in agricultural experimental work.

Life Table. A table showing the number of persons who, out of a given number born or living at a specified age, live to obtain successive higher ages. The same principle may be applied to inanimate objects, such as motor cars, and the results graphed in a "survival curve."

Linear Function. If $y=ax+b$ where a and b are constant, then y is said to be a linear function of x. It is so called because, when plotted on ordinary graph paper, this results in a straight line. If $z=ax+by$, then z is said to be a linear function of x and y. In fact, any equation in which each unknown is of the first order is called linear. But if $y=ax^2+bx$, or $y=ax^n$, it is a non-linear function of x.

Median. After the arithmetic mean, this is the most commonly used kind of average. It is the central or middlemost value. If a series of observations is arranged in ascending order of magnitude, from the smallest to the largest, the median is that value above which fall exactly half the observations and below which fall the other half. For example, the median of 500, 400, 350, 200, 150 is 350. When the number of items is even, the median is located half-way between the two middle items. The median is frequently used to describe the average income in a range of incomes; it was used throughout the report of the Pilkington Commission on medical pay, as also were deciles.

Mode. The most commonly occurring value in a series of observations, the most frequent or typical value. The modal wage, for example, is the wage that is earned by more people than any other wage. The modal shoe size is that size which is taken by more people than any other size.

Non-linear Functions. See linear functions.

Ogive. The graph of a cumulative frequency distribution is called the ogive. This is a term used also in architecture to describe the shape of an arch.

Parameters. A collective name given to statistical measures such as the mean, median, standard deviation, or the proportion of items with a certain characteristic.

Percentiles. See centiles.

Population. This is used statistically in a wider sense than a collection of people. It is the totality of items under investigation — they may be houses, for instance. In making economic and social surveys, a sample is drawn from the total population and the whole object of sampling is to provide information about the population characters which are being investigated.

Quartiles. When data are grouped in ascending order of magnitude from the smallest to the largest, the quartiles divide the range into four parts with an equal number of observations in each. The first or lower quartile is the point below which fall 25 per cent

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of the observations. The second quartile is the point which fall 50 per cent of the observations and is, therefore, the median. The third or upper quartile is the point below which lie 75 per cent of the observations and above which are the top 25 per cent. Quartiles are often used to describe the spread of incomes. The interquartile range is the difference between the upper and lower quartile values.

Quota Sample. A sample, usually of people, in which each investigator is instructed to collect information from an assigned number of individuals (the quota) but the final choice of the individuals is left to him. Each interviewer might be asked, for instance, to question 50 men who are to include at least 10 over 40 years of age, 10 between the ages of 20 and 40, 10 under 20, 10 dressed in lounge suits and 10 dressed in working clothes, and so on. It is a cheaper and quicker method of sampling than random sampling and much used in social and market surveys.

Random Sample. A sample which has been selected from a given population by a method that gives to each item an equal chance of being chosen.

Scatter Diagram. If two sets of measurements have been obtained (say, for a sample of houses, the age and rent of each) and we want to see if there is a relationship between the two variables, each pair of values can be plotted on graph paper. The result is a scatter diagram.

Standard Deviation. This is the most important measure of the dispersion or variability of observations — a measure of the distances or deviations from the mean.

Stochastic. Random. Random variables may be called stochastic or chance variables.

Stratified Sample. In taking this kind of sample, the population is divided into a number of parts or strata, and a random sub-sample of individuals is taken from each part, the number in each sub-sample not being left to chance but being usually proportional to the total population in each stratum.

Survival Curve. See Life Table.

Variable. A quantity which varies. A discrete variable is one which can vary only by jumps, e.g. number of rooms. A continuous variable can take all values.

Weighted Mean. The average of a set of numbers giving due weight or proportion to the relative importance of each. Thus a set of prices or different commodities may be weighted according to the quantities sold, consumed or produced.

MEASURES OF AVERAGES

Monthly Wool Prices (pence per lb.)

In original order			In ascending order			Frequency distribution	
						Range of prices	No. of occurrences
61	56	79	51	63	78	50–54	7
67	65	78	51	65	78	55–59	5
63	62	78	52	66	78	60–64	3
55	66	78	52	67	78	65–69	5
56	70	78	54	67	78	70–74	6
54	78	71	54	69	79	75–79	10
55	78	69	54	70	79	80–84	2
52	78	70	55	70	79	85–89	2
51	82	71	55	71	82		—
51	85	67	56	71	84	Total	40
54	89	71	56	71	85		—
56	84	74	56	74	89		
52	79		61	78			
54	79		62	78			

Arithmetic mean=67.90
Median=69.5
Mode=78.0

Geometric mean=66.98
Harmonic mean=66.05

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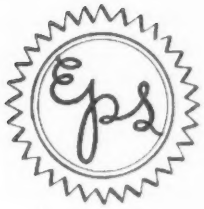
"Long-range planning," according to a study by the Stanford Research Institute, "is one of the most important growth factors. Both high-growth companies and low-growth companies which increased their rate of growth devoted much more time to planning than those companies whose rate of growth slowed down." The Institute also reported that: "Diversification, while highly valuable when properly planned, does not in itself guarantee a rise in rate of growth. Low-growth companies, whose rate of growth failed to increase, actually diversified more than those whose rate of growth improved." How can successful LRP be carried out by growth companies? What are appropriate criteria for effective diversification? Mr. Salveson concentrates on both of these questions in this article.

LONG-RANGE PLANNING IN TECHNICAL INDUSTRIES

By Melvin E. Salveson



Long-range planning is becoming the sine qua non of every corporation which requires a continuing flow of profit for its survival and growth. The factors demanding increased LRP are many and impelling; the more important ones are summarized below. At the same time, the factors mitigating against effective LRP are many and impelling, and also are summarized below. Out of these countervailing forces, a broader view to LRP is suggested here. This view is concerned more with establishing the conditions for long-range "all-weather" *viability* and *profit;* less with attempting to pinpoint specific plans, steps, and events in an amorphous, opaque future. Thus, long-range planning as defined here is concerned with discovering and adapting business operations to the strong patterns and trends which underlie progress and change in an industry or in the economy.

The trends which create the heaviest need for LRP are found in the technical industries. Thus, this report is oriented to those industries. In large part, it is based on studies performed by the Center For Advanced Management for an

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electro-mechanical and electronics manufacturer in a highly technical industry.

A "technical" industry is defined broadly as one in which there is a high degree of scientific or technological knowledge required for performing its processes, for designing its product, or for manufacturing its operations. Typical technical industries include petrochemicals, electronic, aircraft and missile, pharmaceuticals, etc. An insistent problem in these industries requiring LRP is technological, or other, "change." However, the change is qualitatively different from "non-technical" industries, and this difference creates the heightened need for LRP.

The women's garment industry illustrates the basic difference between change in the technical versus the non-technical industries. In that industry, for example, there is change from season to season, year to year, and period to period. A recent scientific study by psychologists indicated these changes are motivated largely by the value of avoiding boredom in the wearer's appeal or attractiveness. Thus, different portions of the anatomy are emphasized under successive style changes; the style at one time emphasizing legs, at another the bust, at another some other portion of the anatomy. The important or significant factor here is, however, that there is no discernible change in the female anatomy. For our purposes it has always had these components, and happily, probably always will. The change is only in its covering apparel. Thus, new knowledge, new form, or new utility is neither created by the style change nor induces that change.

On the other hand, take the electronics industry as a counter example. Change has been frequent in that industry, perhaps up to the rate of change in the women's garment industry, but it has either been induced by or has resulted in new knowledge, new form, new utility. These, in turn, demand in that industry: new business enterprises, new equipment, new methods, differently trained personnel, etc. While some of the ideas and methods presented here may apply both to technical and non-technical industries, the emphasis in this analysis is on the changes, the underlying patterns, and the trends in the technical industries as these relate to long-range planning.

Mr. Salveson proceeds to discuss the difficulties of making good predictions of what sales and profits will result from planned research and development expenditures. The histories of two companies he studied show how greatly cause-and-effect relationships may vary from firm to firm.

The study which is reported here was cued by a large manufacturer's loss of market position and profit. (Call it Company A.) The loss could have been expected three years before it was felt, had top management been alert to the competitor's activities. But it would still have been too late to react and avoid the loss. Importantly, the whole mode of operation during these three years had been as good or better than before, so that the loss was not due to any deficiency in Company A's current operations. Its difficulty arose because it was not concerned with those long-range activities necessary to keep its product and service competitive. The specific event which precipitated the problem for Company A was a smaller competitor's introducing a product based on far more advanced technology, and thereby virtually obsoleting the company's leading line of products. But the lead had been lost several years before the competitor's product appeared on the market; indeed, it had been lost in the laboratory. Company A had to adopt an inordinately expensive "crash" program in order to regain its position.

It is to avert these kinds of reverses that long-range planning is concerned. Day-to-day operations also need to be efficient, of course, but unless they are carried out within the framework of broad, well-conceived LRP, they will lead only to the efficient collapse of profit, leadership, and market position. The following material resulted from analysis of the trends and patterns in the company's industry, and provided the basis for a course of action which would provide the basis for long-range planning and action.

Analysis of the evolution of the industry concerned here revealed a significant fact: *It is impossible to predict.* That is, it was agreed on presentation of the significant inventions and innovations in the industry in a chronology, that even the best informed scientists would have been unable to predict these events or even their incidence, plus or minus five years. The only predictable element was that there had been, and probably would continue to be, invention, innovation, and change, and that the relative frequency of these was roughly proportional to estimated research and development expenditures in the industry, lagged by some range of number of years.

The important Company A top management conclusion and policy in response to this finding were that: (1) The company should plan systematically to spawn a continuing series of these inventions and innovations as the basis for a viable, growing enterprise. (2) It should establish the mechanism for this continuing flow of inventions, innovations, and developments. This flow and the mechanism for it henceforth

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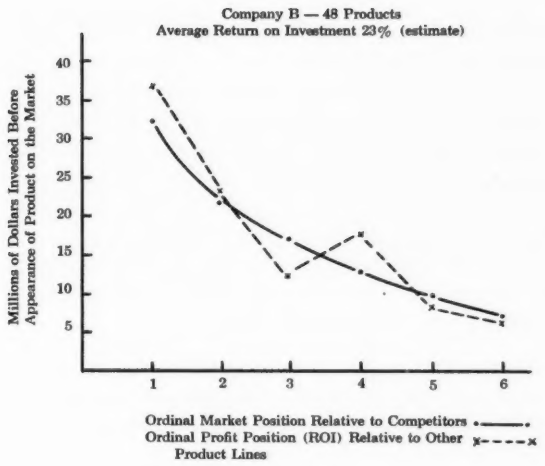
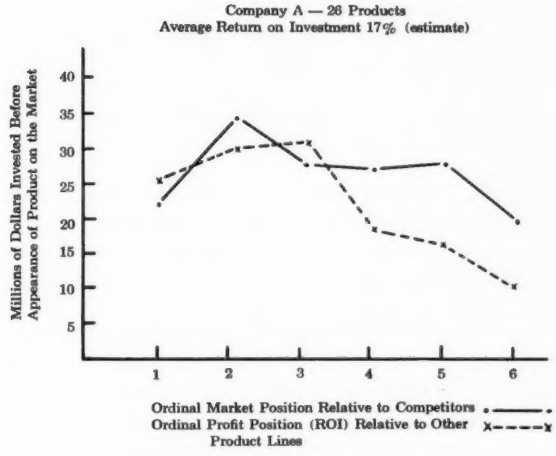


Note: All data are disguised.

Fig. 1



Note: All data are disguised.

Fig. 2

would be considered as important as the flow of materials, goods, and services in producing its current products and the mechanism for that flow, the factory.

At this point, the results of a study made in one of my former employments (Company B) was introduced which reinforced the preceding decision. It also suggested a corroborative study of this company's different products. The purpose of the study was to determine the nature of the "game" which management plays in the long range: the strategies available, their expected pay-offs, and the mixed or pure strategy which should be adopted in the long range.

Figure 1 presents the results of the first-mentioned study. This graph is interpreted as follows: Those products for which that former company was both in first position in its market and had highest return-on-(total product) investment also were the products in which it had invested the most money in the product development (on the average) prior to the original appearance of the product on the market. This is an exciting finding: To make more money, spend more on new product R & D. However, before accepting the hypothesis unequivocally, the concept was tested by a similar analysis of Company A's products. The findings of this study are shown in Figure 2. The results are strikingly different. The meaning of the difference is clear. In Company A, large investment in advance of a product's first appearance did not tend to lead as strongly to first market position. Indeed, relative to some of its second-place products, some of Company A's first-place products had achieved their position with less advance investment.

The study to determine the reasons for the different tendencies gave the following qualitative observations on each company. Company B maintained an aggressive research and development program, with expenditures for R & D very high as a percent of sales, circa 6%. Company A was proportionately almost as aggressive as measured by R & D expenditures as a percent of sales. The difference here did not seem significant.

Company B, through its advertising, company slogans, etc., presented a corporate image of "making progress," where progress included innovation and commercialization. However, it did so very conservatively. For example, one of its former chairmen of the Board remarked, "Fifteen years is about the average period of probation, and during that time the inventor, the promoter, and the investor, who see a great future for an invention, generally lose their shirts. Public demand, even for a great invention, is always slow in developing. That is why the wise capitalist keeps out of exploiting new inventions." [2] [Editor's note: This and other references are listed at the end of the article.] While the policy at Company B subsequently has advanced, it did so only by developing systematic procedures for evaluating when and how, in detail, to develop and commercialize an invention.

On the other hand, Company A, through its corporate image, slogans, and policies, better represents the pioneering inventor. There is good, though nebular, evidence that this image represents the personality and policies of the principal executives. This is a significant difference, even though it is of a qualitative character.

If the preceding difference in fact did exist, it should

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manifest itself in other more measurable ways. The following are some of those ways:

	Co. A	Co. B
1. % of R & D and engineering personnel in		
(a) Central Lab.	54	38
(b) Product Dept. Lab.	46	62
(Presumably reflects relative importance of product oriented and "business controlled" R & D personnel.)		
2. Average number of product lines per department or business profit center. (Presumably reflects the relative importance of any single product line to a single profit-responsible management team.)	6.4	3.1
3. % of product lines directly traceable through evolution to original products without acquisition or merger. (See Figure 3.) (Presumably reflects purposiveness and ability to commercialize on inventions and innovations arising out of R & D related to its existing businesses.)	47	72
4. % of products entering directly into the major overall system produced by the company. (This factor presumably reflects singleness of management purpose in expanding its basic business.)	39	78
5. % of engineering and R & D managers with training in management and business. (Presumably reflects commercial orientation in engineering and R & D.)	16	65 (estimated)
6. % of R & D personnel's time which may be self-directed. (Presumably this reflects relative amount of direction toward company objectives.)	12½%	20%

The author uses General Electric Company to illustrate the amazing evolutionary chain that may exist between a company's founding invention and the businesses it ultimately gets into and thrives in.

These differences cued further studies on the process of innovation, including invention, development, and commercialization. In order to disguise the companies, but yet to give concrete examples of this process, the early experience of the General Electric Company is given. Most examples and references here are from 4, but interestingly they form a striking parallel to the situations uncovered in this study.

> The key person in the process of innovation and commercialization is the engineer-entrepreneur, the person with technical training who can see commercial possibilities in the application of scientific principles and who labors to perfect usable products and techniques. This kind of entrepreneurship has become increasingly important as the advance of science has made available new knowledge, new products, new production methods, and new resources. For in the long view the most significant manner in which to increase economic welfare (and company profit) is not through better administration of existing resources or (socialistic) change in the distribution of income, but through applications of science which increase national income.

Clearly, Company B is predominantly an "engineer-entrepreneur's" enterprise. It deliberately seeks opportunity to commercialize — mindful of the dictates of its chairman that without the test of marketability, any venture would be doomed to failure. It systematically extended its business through accretions always related to its product line, and hence within the market and business which it knew well. Its engineering managers, as the above comparison indicates, have more training in and, presumably, understanding of the problems and methods of commercialization.

Another difference cited by the above comparison is the tendency to emphasize evolutionary entry into businesses. That is, Company B tends to enter companies through expansion into related products or through enlargements of the basic system which it produces and markets. For example:

> The economic orientation of Edison's inventive work in electric lighting defined his approach to the problem of subdividing the electric light (system). His goal was to invent a system which could produce light at the lowest possible cost. And his inventions were inventions primarily because he was looking for a low-cost lighting system. . . . Edison was the first inventor to realize that an incandescent lamp which could operate in a constant-voltage parallel circuit

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would necessarily have to be of high resistance in order to keep the cost of the copper conductors from being prohibitive. . . . Edison's work on the dynamo was also directed toward reducing costs. . . . In each case, he perceived the function of the component in the system. He then determined the characteristic of that component which would result in a *system* with the lowest production cost of light . . . the lamp, the dynamo, and the distribution network were designed to form a lighting system using the minimum amount of resources, with a meter in the system to assure it.

Through the above, we can see the evolutionary chain via which the now General Electric Company entered into its various businesses and product lines, virtually all stemming directly from Edison's original lamp, the protozoa of that company. The General Electric chain of evolution is portrayed in miniature, in Figure 3.

STAGE I

Edison developed the incandescent lamp which he wished to commercialize. Alone it had no future; as part of a complete system he saw it had large potential. This prepared for the next stage.

STAGE II

1. The lamp business "1" required supporting businesses to make and sell a complete lighting system, including:
2. A meter business to supply meters "2" and measure energy consumed.
3. A distribution network business to provide the distribution equipment "3."
4. An energy conversion (thermal to electrical) business, to supply electrical generation apparatus "4."

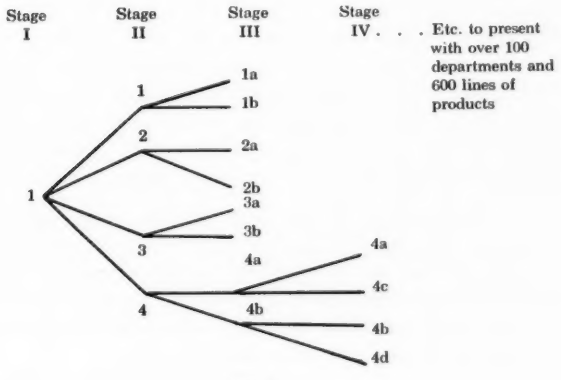

Fig. 3

STAGE III

1. The lamp business, through research on lamps, grew and spawned both indoor "1a" and outdoor lamps "1b."
2. The meter business involved measuring "2a" and instrumentation, thus leading via knowledge of instruments into the instrument business "2b."
3. Research and experience in distribution led to distribution hardware business "3a" through knowledge of electrical hardware and its properties and manufacture. It also led to transformers for conserving copper losses, and thus to the transformer business "3b."
4. The energy conversion business led naturally to knowledge and experience in both prime movers (steam engines and turbines) "4a" and to generators "4b."

STAGE IV

To abbreviate, only a small number of the evolutionary chains are shown and the remainder of the narrative is reduced. Thus, at Stage IV, the prime mover business led to building the engineering and marketing knowledge and skills on which to enter both the steam turbine and gas turbine businesses (the latter of which proliferated later into aircraft gas turbines and shipboard gas turbines). The knowledge and skills in the generator business led directly to the ability to enter also the electrical motor business. While neither aircraft gas turbines nor electric motors are required in the electric incandescent lamp business, pursuit of the latter business by competent engineer-entrepreneurs led to accumulating the knowledge, skill, and insight eventually necessary for entering those businesses.

The full evolution to date (1959) has led to the General Electric Company with over 100 separate departments producing 600 lines of products in as many markets. Some evolutionary links have been terminal ventures, however. For example, governmental action restrained the Company from operating electric utilities; and, the Company found that, though it was helpful to finance these utilities, there was nothing in the skills of the engineer-enterpreneur which made him a good financier. Thus, General Electric withdrew early from the business of financing public utilities.

Arguing that long-range planning requires a sophisticated understanding of the entrepreneurial process, Mr. Salveson lists eight types of knowledge that should be gained.

Return now to long-range planning, per se. Could

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Edison have visualized that his lamp business one day would have led directly to aircraft gas turbines and thence to rocket motors? Of course not; aircraft and rocket motors were unknown at that time. Even within much shorter periods, the links have led to unpredictable new businesses. If Edison, or any other scientist, could not forsee such basic events and turnings in his enterprise, how is is possible to plan for them in the long range?

The answer to the preceding question is in planning for the *flow of invention, innovation, and new businesses* which will evolve. This requires developing a deeper skill in and understanding of the processes of entrepreneurship. Planning for specific inventions and their commercialization is short-term, finite-period planning. This short-range planning requires knowledge and skill in the specific problems of the business to which the planning is directed. The longer range planning for the continuing flow of corporate life blood requires a broader set of knowledge and skills — such as:

1. The general principles of how to design business enterprises, so that whatever evolves from invention and innovation can be profitably pursued or appropriately avoided.
2. How to recognize and develop not only required managerial talent, but more importantly, the entrepreneurial personnel to pursue new business.
3. How to set minimum, maximum, and expected rates of commercializable invention and innovation as the basis for growth and expansion.
4. How to determine criteria for branching at any node in the evolutionary chain, so as to enter only businesses which are compatible with acquired skills, knowledge and the collective self-image and corporate image.
5. How to determine the miscibility of different product lines and businesses into operating businesses.
6. How to establish the conditions and methods for effective entrepreneurship.
7. How to design the parent corporate structure and organization for the "flow of businesses" within that structure, from invention to innovation, to commercialization, and to replacement or abandonment, if appropriate.
8. How to perform the roles of chief executive and corporate staffs in a long-range plan embodying the "flow of businesses." That is, how to manage entrepreneurs, rather than how to manage other managers or individual contributors.

These areas of knowledge and skill would require many more pages to develop than are available here. However, a few paragraphs of explanation are in order.

At this point the author reviews some findings on business development that planners should keep in mind. His comments range from the qualities of innovators to the decay rate of valuable information and key points to watch in predicting the future of a branch operation.

1. *Principles of design of business enterprises.* This area is amply covered by the numerous texts and papers on business organization and management, together with the literature of managing the functional components therein. However, one important lack is techniques for the integration of the various function components into a single system, in the same manner that the engineer performs the system integration and synthesis function in designing a complex system. The newly developing techniques in operations research have important application in the rational design and synthesis of business enterprises; as for example those being developed in the Operations Research and Synthesis Service at General Electric. Perhaps the existence of this service at General Electric reflects that Company's unusual awareness of the need to bring to bear the most advanced and powerful techniques of science and engineering in designing the many evolving businesses within its corporate structure. Toward this objective, and in a separate paper [5] I have attempted to describe methods and techniques for designing business organizations dynamically, in the same manner that engineers must design systems to both static and dynamic criteria.

2. *Development of entrepreneurial talent.* The training and development programs for business are directed toward "managers"; the entrepreneur is hardly recognized. Yet, as Passer relates, "(he) is the key person in this process (of founding and growing new industries based on new technologies)." Unfortunately, the entrepreneur often may be greeted with untoward attitudes in established businesses, unless those businesses are organized to grow on the entrepreneur's labors. For example, Maclaurin [3] writes:

> "Innovations, in fact, may be becoming inherently more difficult. The current trend toward emphasizing smooth human relationships as the principle qualification for administrative responsibility tends to militate against the rise of innovators (entrepreneurs) to top positions."

To innovate and commercialize an invention or dis-

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covery, the entrepreneur necessarily must alter many facets of his environment; change is his function, and new business his output. But the capacity to change, or even to disagree — the first step in effectuating change — is a scarce commodity.

Torrance [6] comments on the modern military entrepreneur, the Jet Ace:

> "Research findings indicate that certain individuals show a generalized willingness to oppose others and disagree when the situation requires it. In our studies of Jet Aces in Korea, we found that this characteristic was typical of the Ace when compared to his less successful colleagues. Asch demonstrated a rather alarming similar picture. In "brainwashing" susceptibility experiments, Asch generated a disagreement between individuals and small groups on a clear and simple matter of fact in the environment. Only one fourth of his subjects adhered to their own correct judgments, when confronted with the different and erroneous judgments of the (experimentally guided) groups."

(The experiments involved deliberate expression of erroneous opinion by the group to determine whether the subjects would maintain their correct opinions. *Three-fourths did not.*)

To plan in the long range requires planned cultivation of entrepreneurs — those who can induce necessary change and who have the other moral and intellectual qualities for business leadership. Unless this key ingredient is provided, the best plan will remain dormant for want of the entrepreneurial spark.

3. *Rate of invention and innovation.* One of the principal findings from the study reported here is that there is a measurable rate of decay of the value of information as contained in products, processes or methods. This is sometimes referred to as obsolescence. However, to recognize it as a problem in maintaining the continuous flow of new information gives the manager and the scientist (or engineer) a better basis for planning the R & D program, for planning the discovery and flow of new information, for anticipating the competitive decay of previously produced information, etc. The consequence of this insight in the study reported here was to study and project the trend in information decay rates, and to estimate the magnitude of the R & D staff and reinvestment required (a) to maintain fixed relative position (b) to gain relative to competitors, assuming both their continuing at current rates and their accelerating their overall reinvestment. The general nature of the findings on information decay rates are illustrated in Figure 4, and provide illuminating insight on the cost of remaining competitive and progressive.

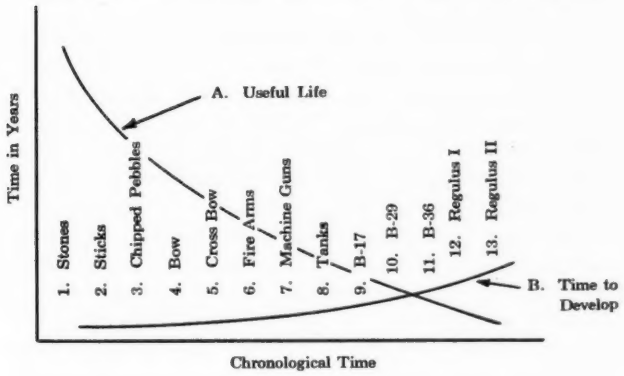

Fig. 4

To protect proprietary information, a weapons systems example is used, and the relative time span is expanded. However, the same trend was observed over short time spans and for a number of commercial products. To illustrate, curve A indicates the useful life of successive competitive weapons systems. Curve B indicates the time (or can be cost) to develop those systems. For example:

> Nelson's tiny flagship was 40 years old and still a first-rate ship-of-the-line at Trafalgar, Halsey's giant Enterprize at three years of age was obsolescent before World War II. The B-17 took circa four years to develop and was operational seven. The B-29 took about six years to develop and was operational four. The B-36 was ten years in development and operational only three. The Navaho was in development six years; it was abandoned before completion because of obsolescence. Regulus I and Regulus II had similar short lives.

Obviously, the increasing cost of R & D and the decreasing life spans of products counteract each other. The former tends to decrease a company's ability to do R & D; the latter increases the need for it. In between these, the rate of commercialization of inventions, then, needs to be controlled so as to insure an optimum program, balanced between the different phases, e.g., R & D, capital investment, advertising, market research, etc. Inasmuch as the problem of balancing and timing the various programs can be phrased in functional equations, it either becomes amenable to solution by calculus of variations, i.e., dynamic programming,[1] or these concepts greatly aid judgment solutions.

The problem is somewhat complicated by the fact that the production or discovery of inventions has elements of uncertainty. This, however, is not difficult to handle if expected, minimum, and maximum rates are used and boundaries or tolerance limits are

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used in the computation. For example, an upper bound(s) may be used to help delimit the number and variety of programs which can be undertaken with available resources. The lower bound(s) determine minimum innovation necessary to maintain given levels of competitiveness. That is, the control of the flow of ideas is instrumental to corporate health; it must be neither too little nor too great.

4. *The criteria for business branching.* The General Electric Company's experience indicates that skills and knowledge are highly transferable, vide the branching and growth from lamps to such things as toasters, turbines, and transformers. However, some branches failed. The successes and failures together provide excellent guide lines. The following are key elements in predicting the success or failure of a branch.

◆ Environmental or institutional knowledge. A working knowledge of trade practices, market characteristics, channels of distribution, contacts with key persons may provide at least part of the basis for a successful branching. For example, National Cash Register Company has had no prior background in large-scale computers. But its very close ties to an important market via a formidable marketing organization well may permit it successfully to enter the business computer field. It offers a point of entry into that business as the business data-processing technology expands and requires integration of the point of initial recording more intimately in the over-all data system.

◆ Technical knowledge and skill. A prime example is General Electric's entry into the electric motor business. An electric motor is essentially a generator run in reverse. Thus, the technical knowledge and skills to design and manufacture generators provided a strong platform for entering the motor business. The basic data involved in the industrial analysis for this kind of branching are similar to those described by Dr. Igor Ansoff. The method described was used by Markowitz and Rowe as the basis for economic and military mobilization planning. The value of the analysis can be large: one company planned to branch into a business but found that the commonality of skills was only apparent, not real. It planned to operate a far-north aircraft engine repair station in the summer and a diesel repair station there during the winter while the diesel tractors were idle. Unfortunately, the skill carry-over from diesel to aircraft parts was too great; the mechanics repaired deisels to aircraft specifications, and vice versa. This was, of course, too costly and inefficient, and had to be abandoned.

◆ Self-image and business flexibility. The self-image to which we refer here is a concept familiar only to those acquainted with psychoanalytic theory. Virtually only those individuals who have been successfully analysed will understand their self-images, and control the operation of them as the determinant of overt behavior. Others are conscious of their self-images only to the extent that they are or are not able to engage in one or another type of social, occupational or other roles, but are not conscious of the reasons for their role inflexibility. An example is cited of a manufacturer of copper hardware that successfully competed in an industrial market where one pattern of occupational roles was required. The company was not successful in a commercial market, primarily because their collective self-images unconsciously made them seek defensive refuge behind the mask of being "conservative engineers." While they consciously rationalized their preference for this role, to the trained observer it was obvious that it was a haven of defense against the incurrence of tensions and anxieties, induced by departing from their protective role. This unconsciously imposed inflexibility caused their commercial operation to be inefficient and unprofitable, even though the company already possessed a strong platform in manufacturing skills and facilities required for that commercial business.

Role inflexibility problems often are resolved by "decentralization" so that each autonomous group, within the same company, can identify with that role(s) implicit in each of the several businesses which is compatible with the group's collective self-image. An alternative, which was used, at least partially in this instance, is a psychoanalytically oriented training program to increase the personnel's flexibility to move between different roles. The organization, in this case, was not large enough to decentralize, hence required multiple role flexibility, through personal flexibility.

The summation of the collection of self-images is the corporate self-image. This latter is one of the most powerful determinants of corporate flexibility — both because it reigns and operates through the unconscious and, hence, cannot be reasoned and reckoned with (except in analysis), and because it is self-reinforcing. No matter what course of action is followed, or attitude projected, they tend to be self-reinforcing: the negative attitudes to be negatively reinforced and the positive, positively reinforced — precisely because one or the other attitude already existed. Hence, the result of performing any business role is to enter that role with such unconscious predilections as create the responses from the environment

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which tend to confirm the predilection, in favor of or against the role.

Obviously, the greater the role flexibility of an individual, or of a business, the greater is its ability to capitalize on opportunities, regardless of the roles which they require. It is of little value to develop long-range plans and programs, only to find that a variety of apparently unrelated obstacles interpose themselves. These may take the form of "that is not our line of business," "the risk is too large," "the economy is uncertain," or other. Alternatively, they may appear as simple inaction, or delay. While it is possible to develop systematically the capacity for role flexibility, it is beyond the scope of this report to describe.

◆ Joint or by-products. A frequent basis for branching is when the production processes yield joint or by-products. This concept is obvious and needs no elaboration here.

The preceding are subject also to legal and moral limitations. For example, General Electric has been restrained by antitrust action from operating public utilities; the aircraft manufacturers from operating airlines, etc. However, these concepts illustrate the evolutionary chain and branches in the growth and diversification of typical, successful, large companies. To reiterate, long-range planning for such growth requires as much the maintenance of the conditions for, and skills of, entrepreneurship as it does the development of specific action programs. Edison, in 1885, could hardly have planned for the evolution of the G. E. lamp business into the toaster and aircraft gas turbine businesses. But he and his successors, by maintaining the conditions for and skills of entrepreneurship, assured that evolution.

What are the most important questions to study in planning company progress? What are the broad requirements of long-range planning?

It was mentioned earlier that there is a minimum regeneration required for maintaining a viable business. Investment in innovation (as in R & D, new markets, new products, or other) must be at least a certain minimum in order to sustain competitiveness and viability. In studying this phenomenon, the following observations were made. There is a distinct, quantifiable, and measureable input-output relationship between successive stages in an innovation cycle. It was found that the "transfer function" can be used in long-range planning. Graphically, it is shown in Figure 5.

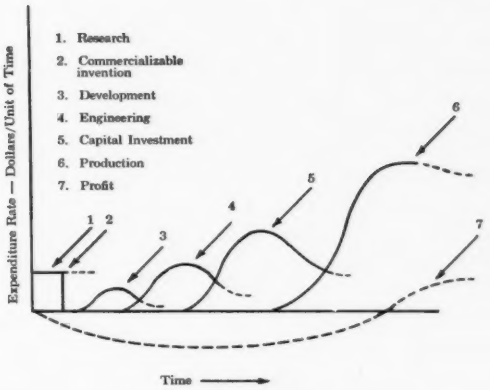

Fig. 5. Innovation Cycle — Expenditure Patterns.

Several important relationships can then be sought for planning purposes. Some of these are:

1. What is the average, minimum, and maximum ratio of the area under each curve to the area under the preceding curve?
2. Is there a trend in these ratios over a period of time; are they increasing or decreasing?
3. What is the characteristic lead-lag relationship between the curves?
4. Do the ratios vary from product line to product line; and, if so, how?

This study was cued by an engineering occupations remuneration study. There, for example, it was found that the higher the rate of innovation in a branch of engineering, the higher the starting and top rates of pay. Similarly, it was found that the higher the rate of innovation in an industry — up to an upper bound — the higher the return-on-investment. It was found that the correlation between R-O-I on a series of products, as a function innovation investment, was not as high as it was on an industry basis. It appeared that there was random fluctuation on a product basis, which was averaged out on an industry basis. In particular, in a whole industry there is opportunity for the operation, not only of primary breakthroughs, but also of supporting or facilitating discoveries.

Thus, it appears that whole industries tend to move together, while within these broad movements, the more aggressive innovators lead the way for the rest. But the leadership tends to be paced by the whole complex of limiting and facilitating innovations and advances.

In broader perspective, long-range planning must answer the question as to the division of innovational resources between:

1. Those programs which lead to lower cost (proportionately less employment).
2. Those which lead to more products.

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In the broad perspective, this is important: if the rate at which the work force is displaced through technological innovation is greater than the rate at which new employment is created on new products and services, unemployment is an inevitable consequence. In a political democracy with free enterprise, this balance can be maintained best through those free enterprises so planning their activities that the opposing tendencies are equilibrated. The alternative is social action, i.e., socialism.

In summary, long-range planning requires or achieves the following:

1. A business-wide perspective in innovation.
2. A continuing flow of innovation for business viability and profits.
3. A set of skills and conditions for successful entrepreneurship within the corporate framework.
4. Organization components for pursuing the processes of entrepreneurship.
5. Adaptation of the collective or business self-image to the roles implicit in foreseeable and evolving businesses, either through increasing personal flexibility or through organizational isolation of the roles (i.e., decentralization).
6. A balanced flow of resources to the phases in the innovation cycle.
7. Recognition of and plans for the gradual reduction in the ratio of the direct labor force to the indirect labor force and overhead, as the result of technological progress.

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POPULARITY OF LRP

Now, at the same time that long-range planning calls for skills of . . . a high analytical order, it requires a different and sometimes conflicting kind of ability. It asks the executive to use his "sixth sense." It asks that he go "visionary" now and then. He needs to look into the future, take calculated risks, imagine possibilities.

We hear a lot these days about how long-range planning is being forced on business because of changed technology, longer lead times, the demand for stable employment, and so forth; but actually the basic *appeal* of planning to top executives — particularly because of the imaginative aspects just mentioned — may account even more importantly for its popularity. After all, the men who guide business destinies today are on the whole an adventurous lot. They are risk-takers. They love challenge. They blaze trails rather than follow them. They create wealth where there was nothing. They are the present-day descendants of the nineteenth-century "captains of industry," the great merchants of the Reinaissance, and the famous traders of ancient Phoenicia. Is it any wonder that they are seizing on long-range planning? It is one of the most potent tools for expansion ever developed.

From David W. Ewing, Editor, *Long-Range Planning for Management*
New York, Harper & Brothers, 1958

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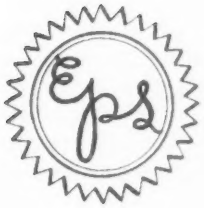
You can't be sure of value if you don't understand the vendor's pricing process, says the Executive Editor of Purchasing. *For most items, prices depend more on buying know-how than on impersonal supply and demand forces. Part of the know-how is in make-or-buy decisions, grouping of orders, and taking advantage of sales gains.*

PRICE ANALYSIS: FIRST STEP TO VALUE

By Dean Ammer



Are prices really determined by impersonal supply and demand forces? This is what most purchasing men have been taught. But few of them really believe it — although they may pay lip service to the idea. If prices actually were determined in impersonal fashion, a major part of the typical purchasing agent's job would be eliminated. The P. A. would only have to worry about quality and delivery; price would be something that was set in some magic way and could never be challenged.

Prices of some items actually are determined impersonally by supply and demand forces. These include commodities traded on exchanges, like copper, crude rubber, etc. Although even these prices are partially influenced by the actions of major sellers and buyers, the typical P. A. would indeed be foolish to attempt to seriously challenge the quoted market prices.

NO FINAL SAY

He can spend his time much more profitably on the

Reprinted by permission from Purchasing, *October 10, 1960, p. 90.*

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administered price items that comprise more than 99% of most companies' purchases of parts, materials, and services. These prices are set by individual sellers. In some cases the prices are rigid and inflexible; producers have sufficient control of the market to arbitrarily set prices and make them stick regardless of the buyer's skill or the state of the market.

In most cases, the seller doesn't have the last word on prices. Able buyers can exert tremendous leverage on prices if they really understand how they are set and don't consider them divinely inspired.

Prices are set by suppliers who are human beings who may not be any smarter than the buyer but who do have somewhat more information available to estimate costs. In a really competitive situation, the supplier's pricing process — even though it may be surrounded by much pseudo-scientific mumbo jumbo — is mostly a matter of outguessing competitors. Each supplier tries to fill his shop with work at the highest possible prices and his bids reflect his eagerness. The competitive bidding process works well for the buyer in such cases. Provided he asks competent suppliers to bid, he is almost always guaranteed good value.

Competitive bidding has its limitations, however. It doesn't automatically guarantee optimum value when there is a limited number of qualified producers of the product or when, for various reasons, there is little price competition among suppliers. On these items — and they comprise a big percentage of the typical company's purchases — the buyer must study the administered pricing process and negotiate skillfully and scientifically.

HIGHER PROFIT MARGINS

The fact is almost every good supplier naturally tries to give the buyer a hard time. A well managed company's research, sales and advertising efforts center on one major objective: to improve the company's products so that they no longer need compete on the rather vulgar (and less profitable) basis of price. If a company can somehow convince its sales prospects that its products are uniquely superior, either by actual improvement or by skillful persuasion, then it won't be eager to shave prices. Successful product differentiation can work wonders on profit margins. Manufacturers in industries that compete almost solely on the basis of price usually consider themselves lucky to eke out a profit of 5% on sales. Manufacturers of genuinely unique products with little direct competition often earn a fat 25-30% on sales.

No intelligent P. A. will be upset by the premium price on a product that is actually different and in which there is little effective competition (like the Polaroid camera, for example). In such cases, the manufacturer is legitimately rewarding himself for his innovation.

Even though the P. A. may calmly pay a premium for a unique product, he should vigorously search for lower cost substitutes of equal quality. His investigation can be particularly profitable when the product differentiation is largely contrived by the seller — that is, when slightly different products work equally well and cost less.

In all cases where competition doesn't regulate prices perfectly, the P. A. shouldn't be bashful about bluntly challenging the supplier's price. When he does, he helps not only his own company but also the supplier and the economy as a whole. When competition is imperfect and prices aren't regulated impersonally by market forces, some other regulatory force is needed. In a totalitarian economy, the force is exerted arbitrarily and stupidly by government bureaucrats. In a free economy it is exerted by the purchasing agent.

Every time a P. A. legitimately challenges a vendor's bid, he forces the vendor to re-check his costs and review ways in which productivity can be increased. Thus the P. A. is a substitute for the impersonal competitive market forces that determine the prices of materials. In this role, purchasing agents collectively are a tremendous force in the overall economy. When they award business to the efficient, low cost producers and force the high cost producers to either mend their ways or go out of business, they help make the over-all economy wealthier and more productive.

HOW PRICES ARE DETERMINED

Although few of them would ever admit it (or even be aware of it), suppliers are also helped when the buyer acts as a substitute for impersonal competitive market forces. They are stimulated to make improvements they might not otherwise. And although sloppy purchasing will certainly permit a supplier to boost profits temporarily, the day of reckoning will come eventually. Only the supplier who is on his toes can hope to get by with high prices, high profits, and average efficiency indefinitely.

Pricing can be a real problem for the supplier if prices are not almost automatically set for him by market forces. In such cases, the supplier's estimate of what the "right" price should be isn't much better than the buyer's estimate. Few suppliers will admit this, of course. But the reasons become obvious when we examine the supplier's pricing process on items

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where competition is limited. In such cases, prices are determined by each producer on the basis of:

1. Costs of production at various levels of output.
2. Selling prices of similar products by competitors.
3. Probable demand at various prices.
4. Profit objectives.

The establishing of an administered price is as much an art as a science. Each of the above four factors must be considered in making the final pricing decision. The final price often represents a compromise among conflicting objectives: e.g., the desired profits may not be achieved because of high costs, lower prices of competitors, or changes in demand.

Effect of Demand. When a supplier gets an inquiry from a buyer, he knows what the immediate demand is. But he might not know what the ultimate demand from the buyer will be. In most cases, the buyer doesn't know either; he can only guess what his own company's prospects are. But he should pass on to the supplier any non-confidential information on future demand in order to negotiate the most realistic price. The buyer should also try to determine what demand, if any, there will be for the supplier's products from buyers in other companies. He won't necessarily get accurate information from the supplier; he may have to base his estimate on his own general knowledge of the market. In general, the stronger the demand for the supplier's products and services, the higher the price the supplier can seek. It is the buyer's job to weaken this demand by finding numerous alternate eager, able and available suppliers.

Competitors' Selling Prices. Every company's sales department tries to keep up-to-date on the selling prices of competitors. On many products the job is easy. Published prices are readily available and producers actually sell at the published prices. For other products, the job is not so easy. Many times, neither buyer nor seller is fully informed on the selling prices of all possible competitors. The buyer is often better informed than the seller since he can always solicit bids from a number of suppliers. But many suppliers are better informed than some buyers give them credit for. Only a foolish (and unethical) buyer will deliberately mislead suppliers on their competitors' selling prices. But a buyer needn't go out of way to tip off his suppliers when his competitors are raising prices either.

Profit Objectives. Well managed companies almost always set specific targets for profits both in relation to sales and in relation to net worth. For example, a company might seek to earn 15% before taxes on sales and 25% on net worth or invested capital. One of the easiest ways to do this is to set selling prices high enough to virtually guarantee success. Almost every supplier will do this if he is permitted to do so by competitors' selling prices, demand, and customer acceptance of his prices. No smart P. A. seriously objects if a supplier achieves his profit objectives. But he prefers to have it done through lower costs and increased efficiency — not through high prices.

REFLECTING DEMAND

Cost of Production. No supplier will willingly sell below his stated costs and any supplier would be foolish to sell for less than his cash out-of-pocket cost. Cost of production is the most important factor in price determination since it sets the minimum level below which prices drop only on rare occasions. The supplier's pricing theoretically rests firmly on his estimates of cost of production. To this cost estimate he adds a profit which reflects his profit objectives moderated by his estimate of competitors' selling prices and demand.

For example, if a supplier calculates that unit costs will total $1.00 on an item and his profit objective is a 20% return on sales, his bid would be $1.20. Up to this point, the estimate may well be made by a junior employee in the cost department. But before the bid is submitted to the customer, a top executive — the sales manager, general manager or president — would study it. It would then be modified to reflect over-all demand and competitors' selling prices. Usually, the bid would be reduced since the profit objective isn't usually reached. But sometimes, if demand were strong or competition were weak, the bid could easily be raised. No executive has ever been fired for earning profits greater than the objective!

Thus the typical supplier's bid leaves the buyer plenty of room for legitimate negotiation. The profit margin is highly flexible and determined at least partly by the seller's estimate of what the traffic will bear. The cost estimate is also quite flexible. No supplier's cost estimate can be much more than an educated guess regardless of how skilled his estimators are. The supplier can accurately estimate his direct cash costs for making the item but he can't hope to do it for his indirect costs. The supplier's cost estimate has three components: material cost, direct labor cost, and overhead cost. Direct material and labor costs can be estimated quite accurately (although, in practice, suppliers' estimates can sometimes be wild for these components too). They are direct costs and represent what the company must pay its workers to produce the item and its suppliers for raw material. While it is certainly not an easy job to estimate direct

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labor and material costs, no policy decisions by management are required.

Estimating overhead costs is more difficult. There are many ways in which overhead costs can be allocated among products and each results in different estimates of unit production costs. In addition, changes in production volume also affect overhead costs. While most companies have cost formulas that permit them to allocate overhead within a tenth of a mil, their controllers would be the first to admit (to anyone but company customers) that their approach is essentially empirical and arbitrary. To see why, it is necessary to study overhead costs in greater detail.

There are three types of manufacturing overhead costs: fixed, non-variable and variable. Fixed overhead means exactly what the term implies. It includes costs that are incurred regardless of how much the plant produces. Real estate taxes, certain insurance premiums, depreciation on buildings and some equipment, salaries of certain personnel like watchmen, all cost the same, regardless of whether the plant is operating at 100% of capacity or only 10%.

Non-variable overhead is not quite as rigid as fixed overhead. It will vary slightly with changes in production volume but will not vary in direct proportion with such changes. For example, when a plant is producing near capacity, there might be a need for two receiving department foremen — one on the first shift and one on the second shift. When the plant is operating at 75% of capacity, these foremen are still needed and non-variable overhead remains unchanged. But when operations are cut back to 40% of capacity, is is possible to get along with one receiving department foreman and "non-variable" overhead varies.

Sales and administrative expense (i. e. the cost of operating the "front office") usually behaves like non-variable manufacturing overhead. It is relatively unresponsive to small changes in sales or production volume. But when there are major changes in sales, it will increase or can be reduced.

Variable overhead is similar to direct labor and direct material costs in that it varies in direct proportion to production volume. If production volume doubles, variable overhead costs also double. Examples of variable overhead include the cost of most public utility services, perishable tools, various operating supplies, and depreciation expense when it is calculated on the basis of machine hours.

FIXED COSTS CREATE PROBLEMS

The fixed and non-variable costs create the problems in pricing. Table I illustrates why this is true. One column in the table shows costs for a hypothetical manufacturer whose production volume is 100,000 of an item he sells for $1.00 each. At this volume, his unit profit is 10¢. Total profit of $10,000 or 10% on sales permits him to achieve his desired return on investment.

Now suppose this manufacturer is able to boost his sales 10% to 110,000 units. Note that his costs do not go up proportionately. They increase by only $5,750 — from $90,000 to $95,750. In other words the additional 10,000 have a unit cost of 57½¢ each ($5,750/10,000). If the manufacturer can maintain his selling price of $1.00 each for the extra volume, he can boost his profits 42½% (from $10,000 to $14,250) with only a 10% increase in sales! The reason for this, of course, is that fixed and non-vari-

Table I. Costs, Profits, and Prices at Two Production Levels

	100,000 Units Production		110,000 Units Production	
	Total Cost	Unit Cost	Total Cost	Unit Cost
Direct Material	$15,000	$.15	$16,500	$.15
Direct Labor	20,000	.20	22,000	.20
Fixed Overhead	25,000	.25	25,000	.225
Non-Variable Overhead	10,000	.10	10,500	.096
Variable Overhead	15,000	.15	16,500	.15
Sales & Administrative Expense	5,000	.05	5,250	.048
Total Operating Cost	$90,000	$.90	$95,750	$.869
Profit	10,000	.10	14,250	.131
Sales (Selling Price)	$100,000	$1.00	$110,000	$1.00
Profit (as % of Sales)	10.0%		13.0%	

This table shows the effect of increases in production volume on unit cost. When volume goes up, fixed overhead is over-absorbed, unit costs decline and open up opportunities for negotiation.

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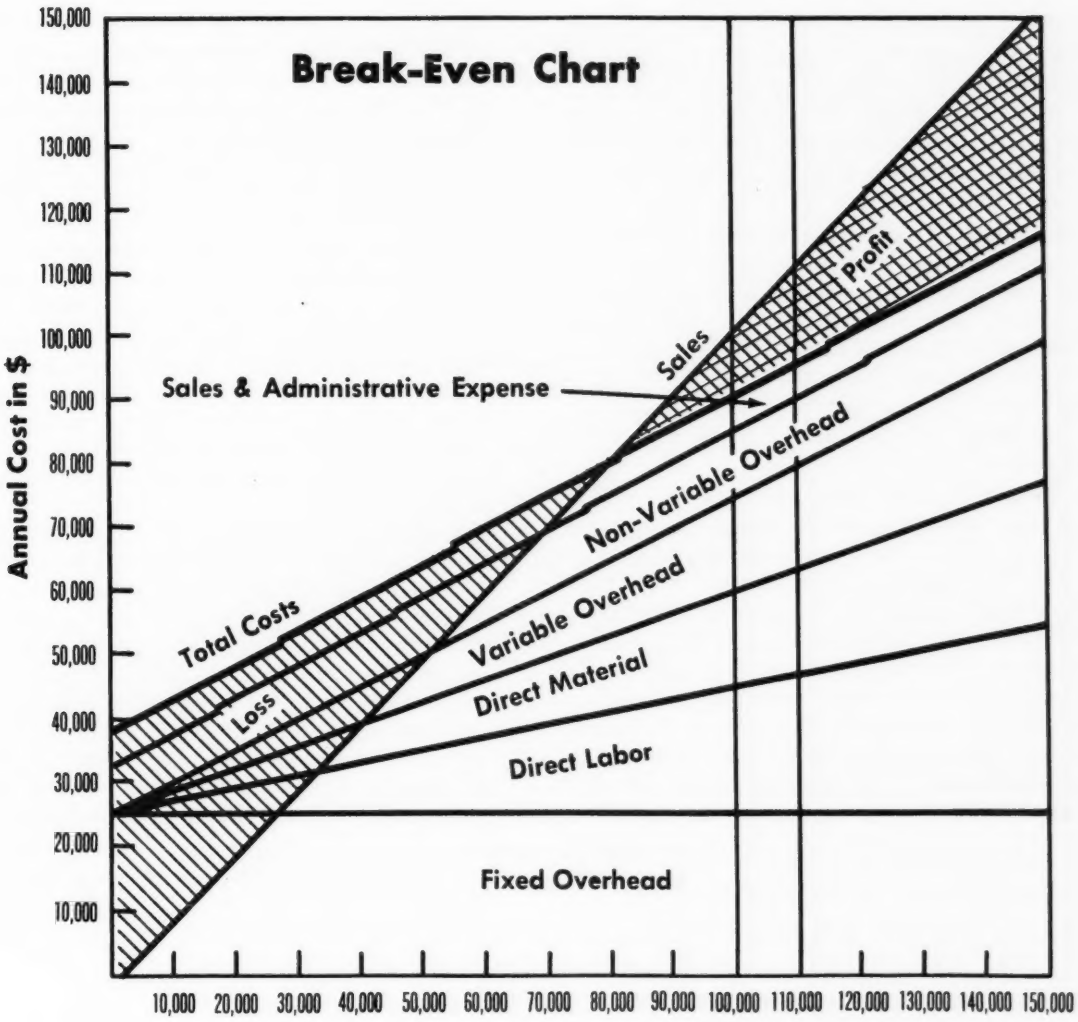

Cost data, such as that illustrated in Table I on the opposite page, is often plotted to graphically illustrate the relation between cost and volume. The result is a break-even chart. Note that the supplier illustrated in our example makes no profit at all when his volume drops to 80,000 units. On the other hand, should he succeed in getting production up to 150,000 units, his profits will be enormous: about $35,000 or over 23% on sales. Although buyers rarely have enough information to construct break-even charts of suppliers, knowledge of the principles involved can be helpful in negotiation.

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able costs do not increase proportionately as output expands. These costs are what accountants call "over-absorbed" — i. e. already paid for by being allocated over a lower level of output.

Of course, if the company could plan on a production of 110,000 units it could cut prices and still achieve its profit objective. If we assume that $10,000 profit provides an adequate return on investment, then a unit profit of just over 9¢ would be required if production were 110,000 units. With costs of $.869 at this level of output (see Table I), the price could be cut from $1.00 to about 96¢.

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DON'T HESITATE TO ASK

The above example indicates that a supplier can accurately forecast his costs only if he can forecast his sales and production volume. Since relatively small changes can cause substantial changes in stated costs, no P. A. need hesitate to ask a supplier to reduce a bid.

Despite the P. A.'s best efforts, manufacturers can usually increase sales without reducing prices when markets are strong and business is booming. The result is sharply higher profits. On the other hand, when sales drop off in a business downturn, suppliers may review costs and decide that it is profitable to sell below "cost" if necessary in order to keep their plants operating at levels sufficient to pay fixed overhead expenses.

The resourceful purchasing executive can exploit his knowledge of the supplier pricing process and the relationship between cost and production volume in both boom and recession. He can do this with make-or-buy decisions, grouping of orders, and by taking advantage of or even exploiting sales gains.

Make or Buy. It sometimes pays to make an item even though it can be bought more cheaply from an outside supplier. The reason, if course, is that when it makes an item a plant is able to absorb some of its fixed overhead costs. This is true only when the plant is operating at a fraction of its normal capacity. When it is operating near capacity, on the other hand, it often is economical to buy items from an outside supplier which can be made much more economically. The reason: costs can soar well over standard when a plant is operated beyond its normal capacity. Expansion may not always be a solution since additional capacity increases the fixed and non-variable costs which must be absorbed.

Grouping of Orders. Many P. A.'s get spectacular cost reductions by offering suppliers a "package" of business for all requirements of a group of similar items. Both buyer and seller benefit since it is possible to process like items in large quantities at lower costs. Production is greater and unit overhead costs are lower. As is obvious from the figures in Table I, a supplier making 100,000 units of an item is often willing to offer price concessions if he can get a customer to take an extra 10,000 units. His costs justify a price reduction and his profits will be greater if he offers a price cut less than his actual reduction in costs.

Exploiting Sales Gains. When business is good, companies buy more from their suppliers. Since the extra volume helps reduce costs, smart P. A.'s don't hesitate to ask their suppliers to pass on the benefits by cutting prices. If suppliers know that no one else will sell the item at lower prices, they will usually refuse to cut prices. (Needless to say, they're usually less than candid about the real reason; usually they insist costs have gone up.) Even when this happens, the buyer's efforts may not have been in vain. In many cases, he can still apply his knowledge of cost. He can persuade suppliers to absorb the increases in wages and material costs that almost inevitably occur when business is good.

CREDIT FROM SUPPLIERS

Suppliers are most likely to consider granting special credit terms when all or most of the following circumstances apply: The customer is one who can be expected to buy important quantities of goods in the future if the special terms are granted; the customer can get equally satisfactory products from other suppliers; the suppliers themselves are well financed; the supplier expects to operate at a rate short of full capacity; and there is evidence that the need for special credit will not last indefinitely. Further, if the supplier is making a large profit margin on the sales, the chances of his agreeing to a special credit deal are enhanced.

Reliance on suppliers for unusual credit arrangements can have weighty disadvantages including the loss of bargaining power on price, delivery, and on other terms. However, firms hard pressed for funds should not overlook the possibility of negotiating special credit terms for new purchases or extended payment terms on existing payables.

From Hunt, Williams, and Donaldson, *Basic Business Finance*
Homewood, Illinois, Richard D. Irwin, Inc., 1958

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Let's face it, says this industrial psychologist. All the talk and research about executive characteristics haven't really got us very far yet. Dr. Taylor is President of Personnel Research and Development Corporation in Cleveland, Ohio. One of the founders of the journal, Personnel Psychology, *he is a former salesman, personnel manager, university professor, and research director.*

THE UNSOLVED RIDDLE OF EXECUTIVE SUCCESS

By Erwin K. Taylor

In every age, in every culture, in every field of human endeavor, a small percentage of people have achieved outstanding success and renown. In these, the uncommon men, there has always been consuming interest. But it is only very recently that our curiosity about them has proceeded from any spirit of scientific detachment. Most of the "study" of the outstanding leaders of the world has been conducted not by scientists — trained, disciplined, and relatively free from bias — but by admirers or detractors concerned mainly to portray their subjects in the most favorable or least alluring light.

Admittedly, the collection of the material needed to produce a great man's biography does constitute, I suppose, what might roughly be called "research." In fact, biographical research in this sense — a practice dating from time immemorial — continues to flourish, despite the growth of the social sciences and the development of techniques and methods aimed at a more rigorous study of the factors accounting for success in a particular walk of life. This, however, is hardly surprising — undoubtedly a skillfully written biography makes more

Reprinted by permission from Personnel, *March-April 1960. The article was adapted from a paper delivered by the author at a University of Wisconsin seminar.*

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interesting reading than the prosaic procedures, totally impersonal data, and cautious conclusions of a scientific monograph.

In biography, then — the extensive though usually biased study of one man — we have what is at once the most primitive and perhaps the most fascinating method of investigating the mainsprings of outstanding achievement. Indeed, whether impelled by admiration or dislike, most biographical research resolves itself into an attempt on the part of the author to establish what he believes to have accounted for his subject's claim to fame. And, it may be added, there is hardly any aspect or attribute of human behavior that has not at some time or other, somewhere or other, been seized upon as constituting the heart of the matter.

LEGACY OF THE PSEUDO SCIENCES

Astrology, phrenology, physiognomy, numerology, graphology — each of these pseudo sciences has had its day, and some for that matter are still with us. But if no enlightened person now believes that a man achieves distinction because of the way he writes his name, the number of letters in it, or the position of the heavenly bodies at the time of either his birth or his conception, a great many people who pride themselves on their intellectual sophistication have been no less ready to accept more fashionable doctrines whose methodology derives directly from the pseudo sciences they would laugh out of court.

The pseudo sciences, both ancient and contemporary, use data as an inebriate does a lamp post — more for support than illumination. Advocates of this, that, or the other system reach a conclusion and then set out to procure evidence in support of it. The evidence is invariably highly selective and uncontrolled. Frequently it takes the form of anecdotes — stories about the great or near-great that prove the point the author is trying to make.

Only recently I met a fairly successful physician who was convinced that a person's life span and accomplishments could be predicted from the weight of the placenta and the length of the umbilical cord at birth. He was endeavoring, when I encountered him, to obtain a sizable grant to enable him to continue his "research" in this area. For several hours, he regaled me with "indisputable evidence" in support of his contention. This evidence consisted, of course, of carefully selected cases in which long-lived, successful people had placentas and umbilical cords of the right weight and length, and of short-lived, unsuccessful people who did not. The stories the worthy physician told were interesting and, to one not trained in the methods of controlled research, most convincing.

The anecdotal method — the selection of evidence to *prove* a hypothesis rather than to *test* it — reaches its finest flowering, however, in the fantasies of the psychoanalysts. Thus a man is a successful salesman, we learn, because as an infant he was rejected by his immediate family. Needing constantly to strive to get what mite of love, affection, and attention was meted out to him, he has become inured to rebuff. One of the disciples of this school, Geraldine Pederson-Krag, has produced the following explanation of the factors that gave rise to a successful sales personality:

> "He was unwelcome to his mother, and his brothers did not want him either. Promising junior members of the neighborhood gang, intent upon proving their manliness with their peers, could hardly be seen with a kid tagging after them. Here began Charles' impulse to say to everyone, 'Please like me,' and 'I am grateful for your attention,' which developed in him a winning, though somewhat obsequious personality. As a man, he expected and accepted rebuffs as he went from place to place soliciting orders." [1]

With the line executive, of course, it was a different story. Of him the author says:

> "Not only was the father the great arbiter of the executive's youth; he was the parent who made the children mind him. His 'No' was the most frustrating monosyllable in the world. He, not the mother, had the means with which to compel obedience, as in the carrying out of chores, having good manners, and observing of a curfew. In this respect, in his relationship to subordinates the production manager resembles the father of his boyhood." [2]

Actually, as often as not, in seeking evidence to support their contentions, the early psychoanalysts ran into anecdotes that clearly contradicted their hypotheses. But it is sometimes easier to invent distorting devices than to abandon pet theories. Being too conscientious merely to ignore contradictory evidence, they invented instead that most useful device known as a "reaction formation." Thus, when a man whose history, like that of our hypothetical salesman, would require that he be deferent, obsequious, grateful for attention, and accepting rebuffs, turns out to be quite the opposite, "Ah-hah!" says the psychoanalyst, "this is precisely what we anticipate. He is reacting or even over-reacting against his own inclinations. Because of his inclination to be deferent, he is aggressive. Because of his inclination to accept rejec-

[1] G. Pederson-Krag, *Personality Factors in Work and Employment*. Funk & Wagnalls, New York, 1955, p. 77.
[2] *Ibid*, p. 82.

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tion, he is hostile. Because of his inclination to be black, he is white; or because of his inclination to be white, he is black."

The sad fact about such unsystematic efforts to support some preconceived theory or hypothesis is that the theory itself could quite conceivably have some merit and partial validity, were it tested scientifically. A good example is afforded by the belief in body-type as a clue to character. Fat men are universally jovial and generous. Beanstalks are cantankerous, careful, compulsive, and so on. This body-type would make a good salesman and that a good banker. We need only to look at the wide variety of somato-types among successful businessmen to give the lie to such vastly over-simplified generalizations; yet Sheldon's careful, painstaking researches at Harvard University have quite convincingly demonstrated that a relationship does exist between somato-type and behavior. Numerous other factors color and distort the picture, but to a certain and certainly limited degree, body-build can be used to predict behavior and performance.

Conceivably, there may be a similar limited validity to some of the less fantastic speculations of the psychoanalysts and in fact, we are now beginning to see the rudiments of scientific research replacing the romantic rituals of the dream doctor's earlier disciples. But we are a long way from the point where the psychoanalysts can be accepted as providing all the answers to the mystery of outstanding achievement.

THE PONTIFICATIONS OF THE SUCCESSFUL

Another approach to the problem of analyzing the nature of success takes the form of conclusions derived from the pontifications of successful people themselves. Thus we listen respectfully while highly placed executives, with the confidence that comes from long occupancy of the driver's seat, tell us what it takes to succeed. But alas, all that the answers invariably boil down to is a list of socially desirable attributes, such as hard work, honesty, and integrity, which most of us flatter ourselves we possess anyway. Then how come no one ever thought to entrust *us* with the destinies of General Motors?

Asking successes to solve for us the riddle of success is about as useful as asking a chicken how to prepare an omelet or a steer the proper way to broil a filet. In fact, in conducting or supervising more than 1,000 intensive executive appraisals, my organization has found that these men have no remarkable degree of insight into their own dynamics. Thus, while there have been numerous systematic surveys designed to ascertain what executives themselves regard as the clues to success, all they tell us is what the opinions of executives are on this subject. But these opinions provide us with no valid answers to the problem.

A good example of the sterility and confusion that results from the attempts to use unsubstantiated executive opinion as research data may be found in the report entitled *What Makes an Executive*, which is a condensation of a Roundtable on Executive Potential and Performance conducted at Columbia University.[3] "This book," says the editor in his foreword, "is a distillation of the thoughts and opinions presented at the Roundtable on Executive Performance and Potential by 17 outstanding figures in business and public affairs." He says further, "The participants realize that, at present, knowledge of executive development was too inadequate for them to give clear-cut answers to the questions with which the field was filled. It was considered more desirable to have the participants draw tentative conclusions from their long and varied experience."

Even in its highly edited form, the Roundtable is frequently discursive and vague. Obviously, the observations of the experts were highly individualized and selective. The points on which consensus was reached were generally points of common knowledge or common superstition. While it may well be that some successful executives have developed keen insight into executive behavior, it is impossible on the basis of pure pontification alone to differentiate between such insight and the simple tendency of successful men to attribute success to the characteristics they believe themselves to possess.

Possibly the first attempts at executive research that merit the term "scientific" were the demographical studies undertaken primarily by sociologists. These deal with the vital statistics — the background, socio-economic status, education, and so on — of men who have become successful executives. An early classic example was the study by Taussig and Joslyn, who collected their data in 1928 and published their findings in 1932. Their conclusions were that it was becoming increasingly difficult for anyone but the sons of business owners or business executives to become successful businessmen themselves and they predicted that by now two-thirds of management would be drawn from this narrow source. But Warner and Abegglen, collecting similar data in 1952, found just the opposite trend from that predicted by Taussig and Joslyn, and their findings were substantially the same as those of a similar study by Mabel Newcomer.

[3] E. Ginzberg (Ed.), *What Makes an Executive*. Columbia University Press, New York, 1955.

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LIMITATIONS OF DEMOGRAPHICAL APPROACH

These demographical studies are frequently rather naïve, however, from the point of view of research design and data interpretation. Thus Warner and Abegglen, while concluding that our social system "continues to make it possible for men of all levels to move into elite positions in commerce and industry," aver:

> "Only to a limited extent may it be said that every man's chances are as good as the next man's, for birth in the higher occupational levels improves these life chances considerably. If equal opportunity were realized in practice, the business elite and the nation as a whole would share a common background, whereas the composition of the business elite is clearly weighted toward the higher occupational levels of our society." [4]

For this statement to be valid, it would be necessary to assume either that talent is unrelated to socio-economic status or that it is unnecessary for success. Now, while it cannot be denied that family affluence is of some value in affording environmental and educational advantages to the growing youth, genetics cannot be completely overlooked. Desirable propensities are no less genetically determined in the human organism than in corn, cattle, or cauliflower — and family affluence is surely evidence of some superiority in the strain. It is significant that the occupations of the fathers of the business leaders studied were taken as of the time the leaders themselves were in their late teens. This would place the parents' age in their early forties. Thus the fathers, at the time their occupations were noted, would in most cases be close to the peak of their career level. Obviously, the more talented, ambitious, and mobile fathers, even from humble beginnings, would have reached substantial levels by the time they were forty. Fortunately, Warner and Abegglen also noted the occupations of the leaders' grandfathers. The evidence of upward mobility is clear from these figures:

Occupation	*Grandfather*	*Father*
Clerk	2%	8%
Minor executive	3%	11%
Professional	10%	14%
Big business	12%	24%
Owner small business	17%	18%
Laborer	19%	15%
Farmer	35%	9%

A somewhat similar situation exists with respect to the relation of education to achievement. All the demographical studies point to the growing proportion of college-trained men among successful executives — a situation that led Vance Packard, in *The Status Seekers*, to make quite a to-do about what he dubbed the "diploma elite."

Two factors, in particular, stand out as mitigating the possible interpretation of this trend as "evil." First, none of the studies appears to take cognizance of the obvious fact that the extensive technical progress of the past half century has required trained technicians, engineers, and scientists to become part and parcel of the management team. It may be assumed that some of these men were also sufficiently talented administratively to rise to the high positions studied by these investigators. Second, and more importantly, the studies gloss over the fact that practically 25 per cent of the American population now goes to college as opposed to a mere 5 per cent at the turn of the century. What better screening device can industry find than the successful negotiation of a college

[4] W. L. Warner and J. Abegglen, *Big Business Leaders in America*. Harper & Brothers, New York, 1955, p. 14.

BIG PROBLEMS AND A LITTLE PROGRESS

What management wants to know is (1) how to select the men most capable of becoming good managers and (2) how best to prepare these men for more responsibility. The task may seem simple enough on the surface but it is riddled with serious problems — for instance:

- It is hard enough to measure success quantitatively for routine factory and clerical jobs. When it comes to top management jobs, questions arise not only as to *how well* an individual is performing but also as to *what* he is performing.
- The higher the position, the more it tends to be altered by the executive holding it, viz., "the man makes the job."
- What makes for successful managerial performance depends in part on what the boss thinks is successful — and bosses' opinions on this range all over.
- The very fact that behavioral scientists are known to be studying the behavior of an executive group is likely to throw the results of an experiment off.

However, the problems are not insuperable. Already there are useful fragments of research to put in the puzzle. For example:

- Tests by Dr. William E. Henry showed that a strong desire for achievement was an outstanding characteristic of the successful executives he studied.
- Another psychological study showed that among managers and professional people, initiative tended to increase with age — while decreasing with age in the case of other workers.
- Some careful researches "have quite convincingly demonstrated that a relationship does exist between somato-type and behavior."
- Demographical studies have pointed to a growing proportion of college-trained men among successful executives.

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curriculum? While undoubtedly some talented people will be overlooked if selection is restricted to college graduates exclusively (and for that matter no selection method yet devised is proof against the possibility of missing a good candidate), it would certainly be folly to ignore college achievement in the endeavor to make selection more "democratic." Industry selects college graduates for the simple reason that, on the whole, better educated people are more likely to make successful executives. Packard's statement that there are as many talented youngsters in the lower as in the higher socio-economic classes may be literally true. What he does not say is that their proportions are vastly different.

It should also be noted that the demographical studies have dealt with high-level executives — presidents and chairmen of the boards of large corporations. This concentration of examples of what we might call "extreme success," while it clarifies trends, sometimes obfuscates realities. Conclusions about the origin, background, and education of these top-level executives cannot be generalized for management as a whole. The extent to which those who have risen to the top in large companies come from higher socio-economic backgrounds and are better educated than the general management population is, however, indicative of the fact that these characteristics are validly related to talent. This is particularly true in the larger corporations where, as Newcomer points out, position is much less often inherited than in smaller ones.

Thus, while the demographical researches have been important in pointing out the background factors associated with business success, they are not particularly penetrating and have limited usefulness both to the individual executive who is looking for clues to success and to the organization that is seeking to increase the effectiveness of its management team.

THE KEY QUESTIONS

Actually, only during the past quarter century has American industry become aware that an "executive problem" exists. Almost until the end of World War II a sort of *laissez-faire*, sink-or-swim philosophy of management appears to have permeated our culture. As business enterprises have grown and their management problems have become more complex, policy-making executives have become increasingly aware that the future success of their enterprises depends in large measure upon the quality of their management personnel from the first-line foreman up. What management wanted and still wants to know is: (1) How to select the men most likely to perform the managerial function successfully and (2) what steps should be taken to prepare those with identified potential for greater responsibility in the future.

These questions, unfortunately, are not nearly so simple as they may seem on the surface. Before we can find out how to select men who will be successful in managerial positions, obviously we must know what we mean by success and must be able to measure it quantitatively. This problem of performance evaluation, even for routine factory and clerical jobs, has proved over the years to be an extremely difficult one technically, fraught with all sorts of pitfalls. And its complexity is compounded as we rise in the management hierarchy. At the lowest levels, what is expected of the individual can be found out with a fair degree of specificity. The job objectives at these levels are generally short ranged and job activities are fairly observable. But as we go from echelon to echelon, from worker to foreman to middle manager to top executive, the range of job objectives in a time-sense becomes broader; it becomes more difficult to determine by simple observation not only *how well* an individual is performing but even *what* he is performing.

Thus before researchers could study ways and means of measuring successful executive performance, techniques for identifying what executive positions consisted of in terms of their functions and objectives had to be devised. And it did not take a great deal of exploration to discover that the higher the position, the more it tended on the whole to be altered in its essence by its incumbent. Low-level jobs are fairly tightly structured and the men holding them have little opportunity, relatively speaking, to change them. But as we go up the ladder, the truth of the old adage, "the man makes the job," becomes more and more apparent.

Some years ago, under the auspices of the Adjutant General's Office, we interviewed 100 infantry company commanders to find out how each conceived of his job. It would be difficult to find anywhere in the industrial situation 100 positions as identical as these. Yet, we were amazed to find in analyzing the results the extent to which these officers varied in the way they interpreted their job duties and responsibilities. At one extreme were men who went by the letter of the regulations and saw their duties as narrowly confined and restricted. At the other were those who took a broad view of their assignment — the men who said, in effect, "It is my job to do or to see that everything is done needed to accomplish the mission of my company and to look after and protect the welfare of my men."

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Simultaneously, we also interviewed the immediate superiors of these company commanders to determine their expectations with reference to their subordinates. Here, too, we found the same range of differences. Some superiors expected their company commanders to perform strictly in compliance with regulations while others expected their subordinates to use regulations mainly as a guide to help them accomplish a broadly defined mission. Further, we found that whether a company commander was considered effective by his superior had nothing to do with whether he conceived his job broadly or narrowly. Rather, this was a function of the extent to which his concept of his job *agreed* with his superior's concept of what the subordinate's job should be. Thus we see how closely intertwined the two aspects of executive functions can become and the complexity of the relationship between them.

WHY BEHAVIORAL RESEARCH HAS LAGGED

Industry, unfortunately, has not always appreciated the complexity of the questions to which it is seeking answers. Companies for the most part have wanted neatly packaged programs, not research. Even the most progressive organizations, proud of their shiny research centers and their bright young physicists, chemists, and research engineers, rarely engage in comparable activities in the behavioral sciences. There are, perhaps, two reasons for this. First, executives, being human beings, frequently feel that they intuitively know the answers to the questions they raise and require only the machinery to implement their preconceptions. As a colleague of mine aptly put it when I asked him why he had abandoned personnel research for another branch of psychology, "It is too difficult to be a professional in a field in which everybody is an expert."

Second, the behavioral sciences differ in one significant way from the physical sciences. A company can build a research laboratory isolated from its producing organization and, without interfering with its regular production, forthwith embark on research to develop new products or improve old ones. The automatic transmission or the new alloy that the physical scientists are working on is in no way affected by the fact that the problem is being tackled in the artificial environment of the laboratory. With the behavioral sciences, this, of course, is not the case. Even if it were economically feasible to set up a fully staffed industrial corporation for purely experimental purposes, the very knowledge that it was experimental, as the famous Hawthorne studies demonstrate, would seriously distort the results.

Behavioral research, consequently, must be done with real executives functioning in a "for keeps" situation. Though various games and exercises have been devised to overcome this difficulty, we cannot yet say with any degree of certainty how valuable they will prove as a research tool. However, we can be pretty sure that even at best they will be a poor substitute for the real thing.

In passing it may be noted that the Armed Forces have taken a much more progressive view than has business of the need for research in the executive area. The Personnel Research Branch of the Adjutant General's Office, the Personnel Laboratory of the Air Force, and the Office of Naval Research have sponsored and conducted research which is at least a decade ahead of what most American industry has accomplished. In most cases, such research as has been carried out by industry has been peripheral and piecemeal rather than on any organized and systematic basis.

In one of the classic studies, Dr. William E. Henry, of the University of Chicago, administered the Thematic Apperception Test to several hundred successful executives from a wide range of companies. While there were marked variations among the responses of these men, a strong desire for achievement was the outstanding characteristic of this particular population. These executives were mobile and did not form deep roots or strong ties. They were men who looked upon authority figures as helpful and, as might be expected, displayed considerable decisiveness. On the negative side, they were continually dogged by the fear of failure, prone to excessive concern about their health, and frequently displayed a variety of hypochondriacal symptoms. Unfortunately, Dr. Henry either did not or could not match his sample of successful executives with a control group matched in respect to such factors as age, marital status, and socio-economic and educational background. As a result, the characteristics he ascribes to executives are not necessarily peculiar to them—a flaw unfortunately common to many of the researches in this area.

MEASURING INITIATIVE

In another study, Ghiselli developed a rather simple measure of initiative which he administered to 608 employed people ranging from operators and laborers to managerial and professional personnel. He found that while his measure of initiative correlated only modestly with intelligence, it did correlate substantially with his measure of self-assurance. Interestingly, also, he found that among his professional and managerial workers initiative increased with age, whereas

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for the population as a whole there is a slight drop from age 20 to age 69. However, among the line workers studied the drop was moderate up to age 40 and substantial thereafter. As one goes up the socio-economic scale from industrial workers to top management personnel, there is a steady and consistent rise in initiative scores.

I mention these two studies merely as an illustration of the innumerable pieces of fragmentary research to be found in the technical literature. Because of vast differences in the nature of the populations studied, the research design employed, the instruments used, and a dozen other such uncontrolled variables, it is impossible at this stage to draw any generalizations based on comprehensive, consistent research about the characteristics of successful executives or even, for that matter, to define what a successful executive is.

BEYOND THE THRESHOLD

In short, while interest in and speculation about the nature of success is as old as history itself, bona fide research in this area — research that is competently designed and proficiently executed—has hardly progressed beyond the embryonic stage. The horizon is dotted with isolated examples of sound studies, such as those conducted by the Personnel Research Board at Ohio State University and the Educational Testing Service at Princeton. But we still have a very long way to go.

Executives function in a wide variety of complex environments. They succeed or fail for an equally wide variety of different reasons. No single, dramatic research study is likely to produce an explosive break-through that will provide a simple answer to the riddle of outstanding achievement in the business world. Nevertheless, the behavioral sciences have now advanced to the point where, given the resources and the time, they can make substantial inroads on this highly involved problem.

If industry is sincere in the importance it ascribes to the problem of selecting and training its management personnel, the time has come for it to back up its belief with the dollar and man-hour resources that will enable competent behavioral scientists to plan and conduct long-range researches that will not be the first thing to be scrapped whenever circumstances decree another round of economic belt tightening.

Further, industry must be prepared for the fact that many of the resources poured into executive research will go down the drain. This is only to be expected — it is the nature of all research. But even the failures will teach us something — at all events, we'll learn from them what won't work. And, out of heightened, competent research efforts, worthwhile answers will slowly but surely emerge.

POWER OF LEADERSHIP

The power of leadership lies in that very creative ability to build and present to the vast and uncritical multitude the particular fiction that sums up for its members the reality in which they find themselves and the hope they have of coping with it successfully. Mr. Roosevelt's famous "fear" statement and, of course, Sir Winston Churchill's equally famous "blood, sweat, toil and tears" phrase were such fictions. The people who responded to them did so chiefly because, like most of us, they were living, as we tend to live, in the past. Their feelings about the present and future, as ours generally are, were tentative and unresolved. The magnificent gift of the truly creative person is to be able to advance his particular area of activity a little further into the unresearched future. And he does this by creating fictions which conveniently explain the unknown to those of us who cannot imagine it. Actually he does not completely anticipate what people want — rather, he articulates it for them, and makes clear what they need.

From Walter Weir, "*The Elusive Element in Scientific Marketing*"
Reprinted from *Journal of Marketing* in *Challenging Business Briefs*,
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